ASTRONOMY

December 1982
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Yerkes: a Celebration of Light

Stars That Touch

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The Pleiades

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Telescopes Shown: *(top) Meade 8″ Model 2080 with optional photographic systems, including 4″ Schmidt-Cassegrain Photo-Guide Telescope; and (bottom) Meade 10″ Model 2120 with optional 2″ f/12 Photo-Guide Telescope.*

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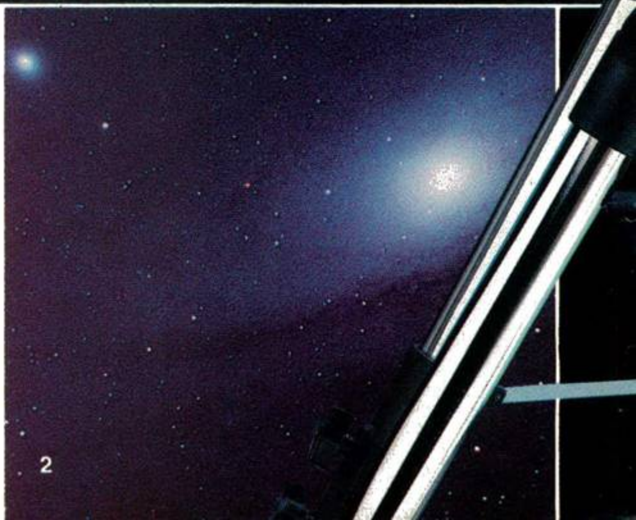
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All astrophotographs shown on these pages were taken through off-the-shelf, unmodified Meade 8″ Model 2080 Schmidt-Cassegrain telescopes. For further technical details on these and many other astronomical photographs, send for your free copy of the Meade Schmidt-Cassegrain Astrophoto Brochure. (Alternately, the complete Meade 52-page General Catalog is available at $3.00 by First Class Mail and includes the Astrophoto Brochure at no additional charge.)

Key to Photographs
1, 2, 3, 5, 7 — Leo Henzl; 4, 6, 8 — Emery Hildebrand;
9 — John Sanford

1. Orion Nebula M42; exposure time 50 mins. **2.** Andromeda Galaxy M31; 60 mins. **3.** Galaxy M82; 60 mins. **4.** Milky Way in Sagittarius (50mm piggyback photo). **5.** Spiral Galaxy M33; 75 mins. **6.** Spiral Galaxy M51; 60 mins. **7.** Galaxy NGC 253; 40 mins. **8.** Omega Nebula M17; 40 mins.; **9.** Moon — Clavius region; 1-sec.

ASTRONOMY

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The World's Most Beautiful Astronomy Magazine • Established by Stephen A. Walther

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Cover: December marks the return of winter — and few celestial objects symbolize the winter skies better than the colorful open star cluster the Pleiades. Photograph by Orien Ernest. These pages: This month, ASTRONOMY takes you on a tour of one of the world's most renowned astronomical institutions, Yerkes Observatory. Here, bathed in the dim ruddy glow of the dome's night lights, an observer is at the controls of the largest refracting telescope ever made — the great 40-inch. Photo by Bruce Bond.

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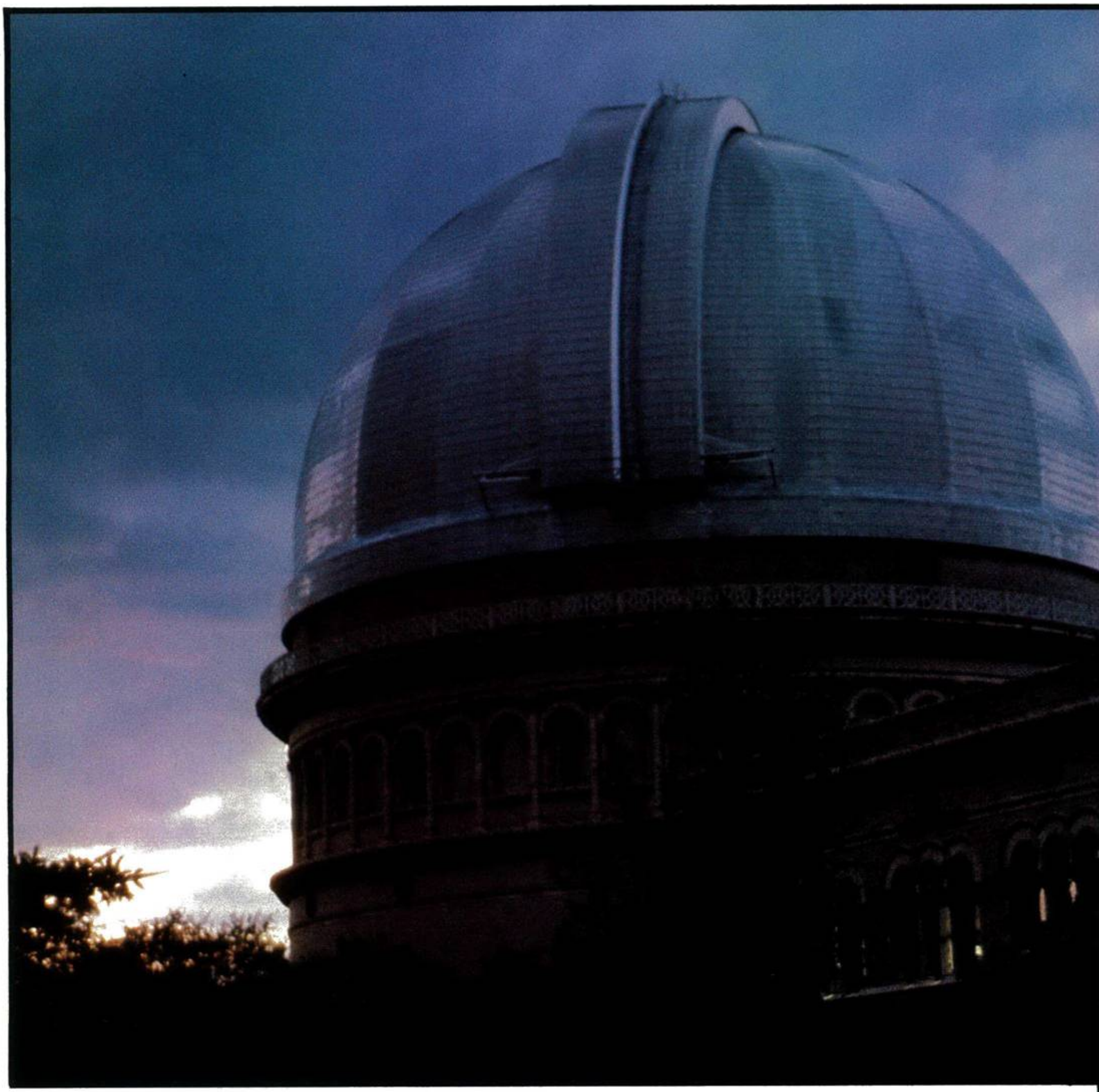
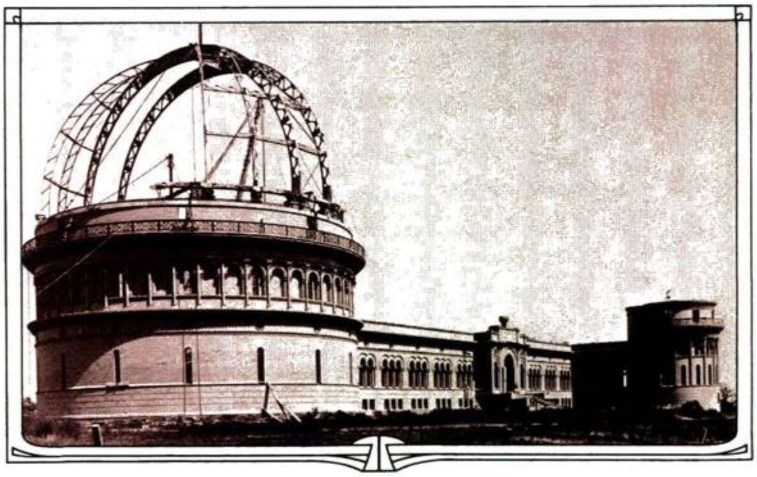


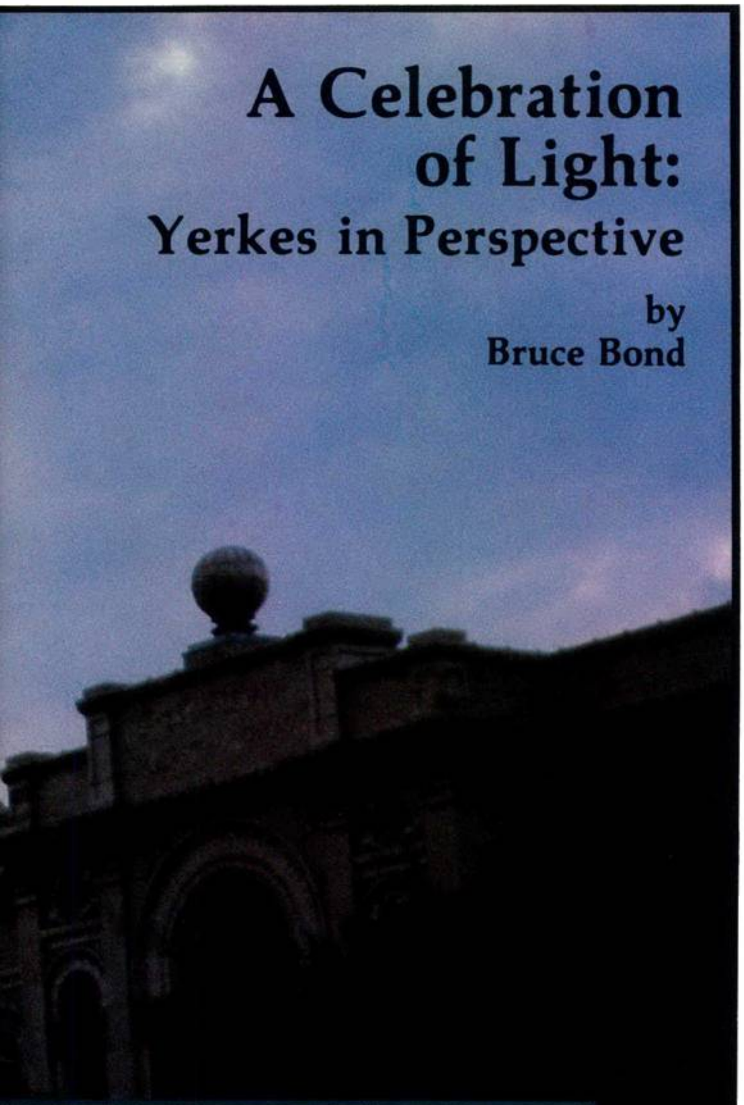
Above: Yerkes Observatory and the dome of the 40-inch as seen from the southeast. (Except as noted, all art and photos are by the author.)

Right: A view from the southwest showing the steel skeleton of the dome for the 40-inch.

Far right: Astronomer George van Biesbroeck in 1918.

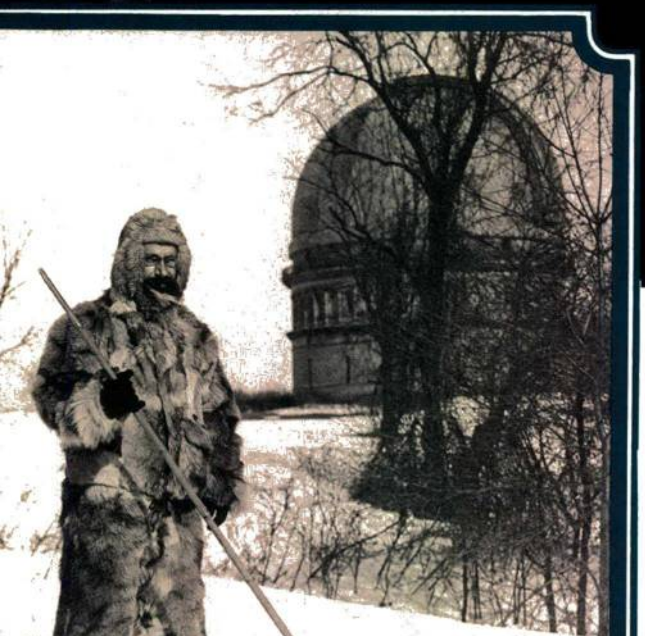


Yerkes Observatory



A Celebration of Light: Yerkes in Perspective

by
Bruce Bond



Yerkes Observatory

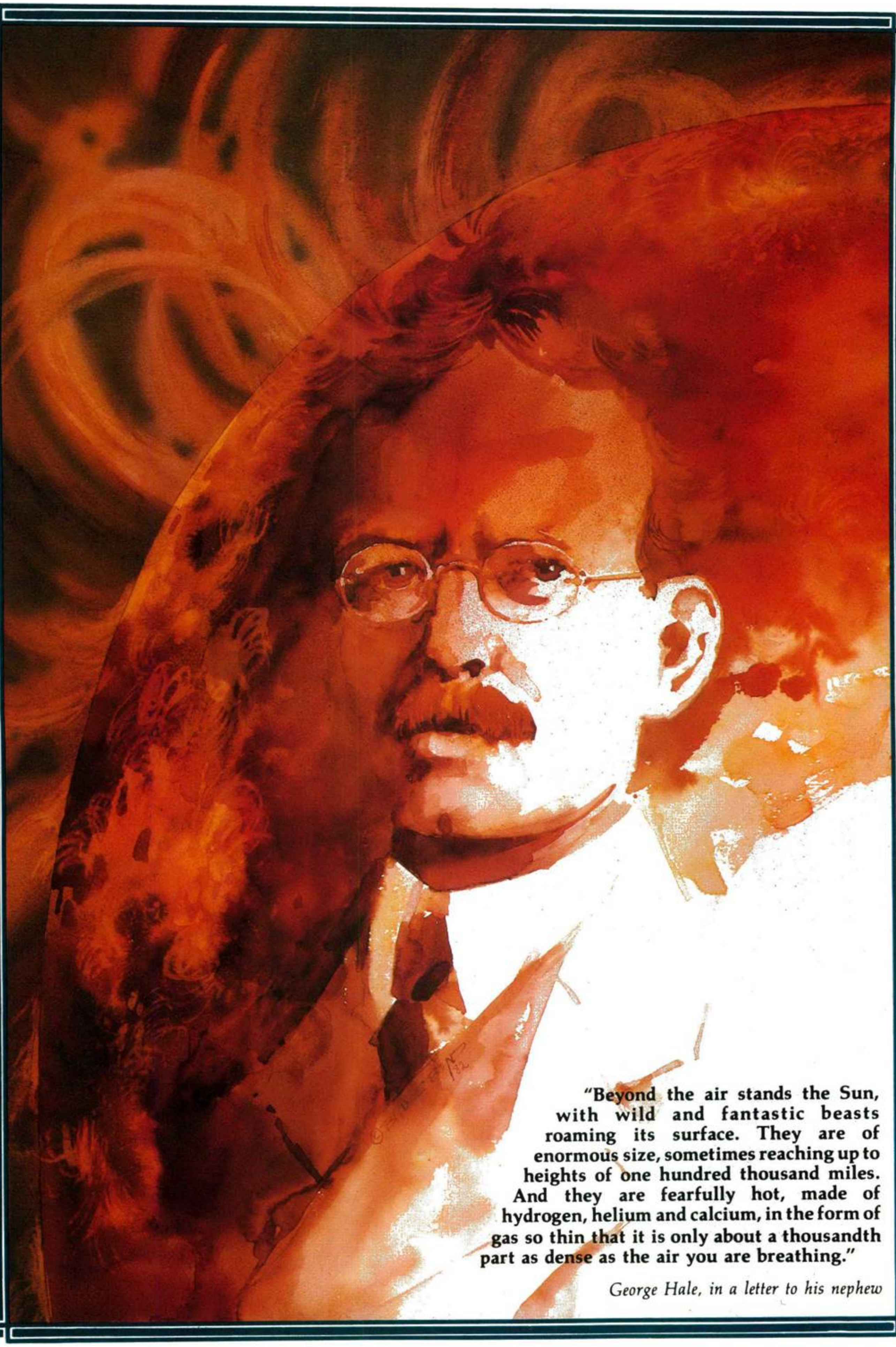
Twelve thousand years ago, the last glacier left its imprint in the terminal moraines of southern Wisconsin. As the boreal centuries warmed to life, animals, plants, and peoples of the woodland cultures returned to populate the forests and prairies.

One of the most revered and sacred Pottawatomi Indian villages and burial sites was located on the shore of a small deep lake, eventually called Lake Geneva by the white settlers. The surrounding territory was sold to the United States Government at the conclusion of the Black Hawk War in 1832. Not long after, these fertile lands of northern Illinois and southern Wisconsin were densely settled with large populations centered in Chicago, Milwaukee, and Madison.

Throughout the 19th century, the United States was largely a scientific backwater. A few institutions located on the east coast had begun to make names for themselves, but international recognition came slowly — and, scientifically speaking, the midwest was hardly more than raw frontier.

But things were astir. In 1890 the fledgling University of Chicago, under its president, William Harper, had begun a vigorous campaign to build itself into a first-rate institution. An important part of that program was a strong department of astronomy and astrophysics — and here, Harper sought the services of a recent physics graduate of M.I.T., George Ellery Hale. Hale had returned to Chicago to found his own Kenwood Observatory at his father's home on Drexel Boulevard. There he planned to pursue studies of the Sun's spectrum using an invention of his own, the spectroheliograph.

Hale knew, however, that his research would eventually require better instrumentation and a larger telescope than the 12-inch refractor at Kenwood. Eager to further his own work and to stimulate that of others, the 24-year-old Hale joined



"Beyond the air stands the Sun, with wild and fantastic beasts roaming its surface. They are of enormous size, sometimes reaching up to heights of one hundred thousand miles. And they are fearfully hot, made of hydrogen, helium and calcium, in the form of gas so thin that it is only about a thousandth part as dense as the air you are breathing."

George Hale, in a letter to his nephew

the new University of Chicago as associate professor of astrophysics.

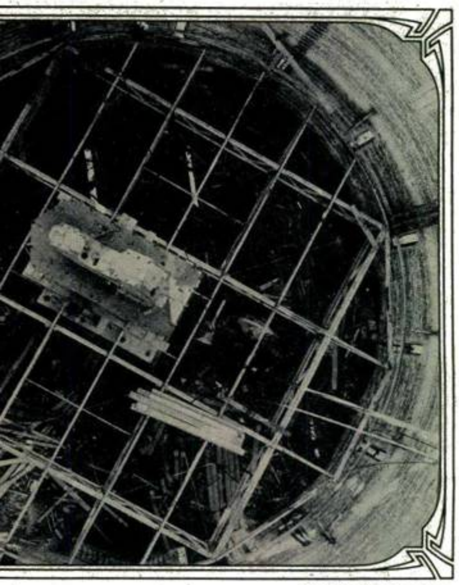
Soon after, at a scientific meeting during the summer of 1892, Hale learned that a pair of 40-inch diameter glass disks were available. Alvan G. Clark, the great telescope maker of Cambridge, Massachusetts, had tested the glass — made by the firm of Mantois in Paris — and found them perfect. Recognizing that this was an opportunity to obtain the world's largest refracting telescope, Hale approached Harper with the idea of acquiring the instrument as the mainstay of an observatory for the university. Harper was convinced, and soon a search for contributors to finance the project was underway.

Consultations with his father and other influential businessmen led Hale to approach Charles T. Yerkes, a wealthy Chicago street-car magnate. Meeting with Yerkes, Harper and Hale were so persuasive that in mid-interview the contract with Alvan Clark for the 40-inch objective lens was telegraphed to Cambridge.

But there is far more to an observatory than the lens of its main telescope. Many more efforts were made as the project developed to pursuade Yerkes to fund the necessary other ingredients of the observatory. Yerkes agreed to pay for the mounting and one additional instrument, a stellar spectograph.

Committed somewhat against his will to these items, Yerkes refused to budge any further — until he saw the magnificent plans for the building drawn up by Henry Ives Cobb, the university architect. Inspired by the Potsdam Observatory near Berlin, the design of the new observatory was intended to fulfill Hale's dream of the world's most modern and fully-equipped astrophysical laboratory, a place of reknown in the world of science. It was to be called the Yerkes Observatory. Persuaded at last, Yerkes agreed to underwrite the entire project, with the university guaranteeing to maintain the observatory on an adequate scale.

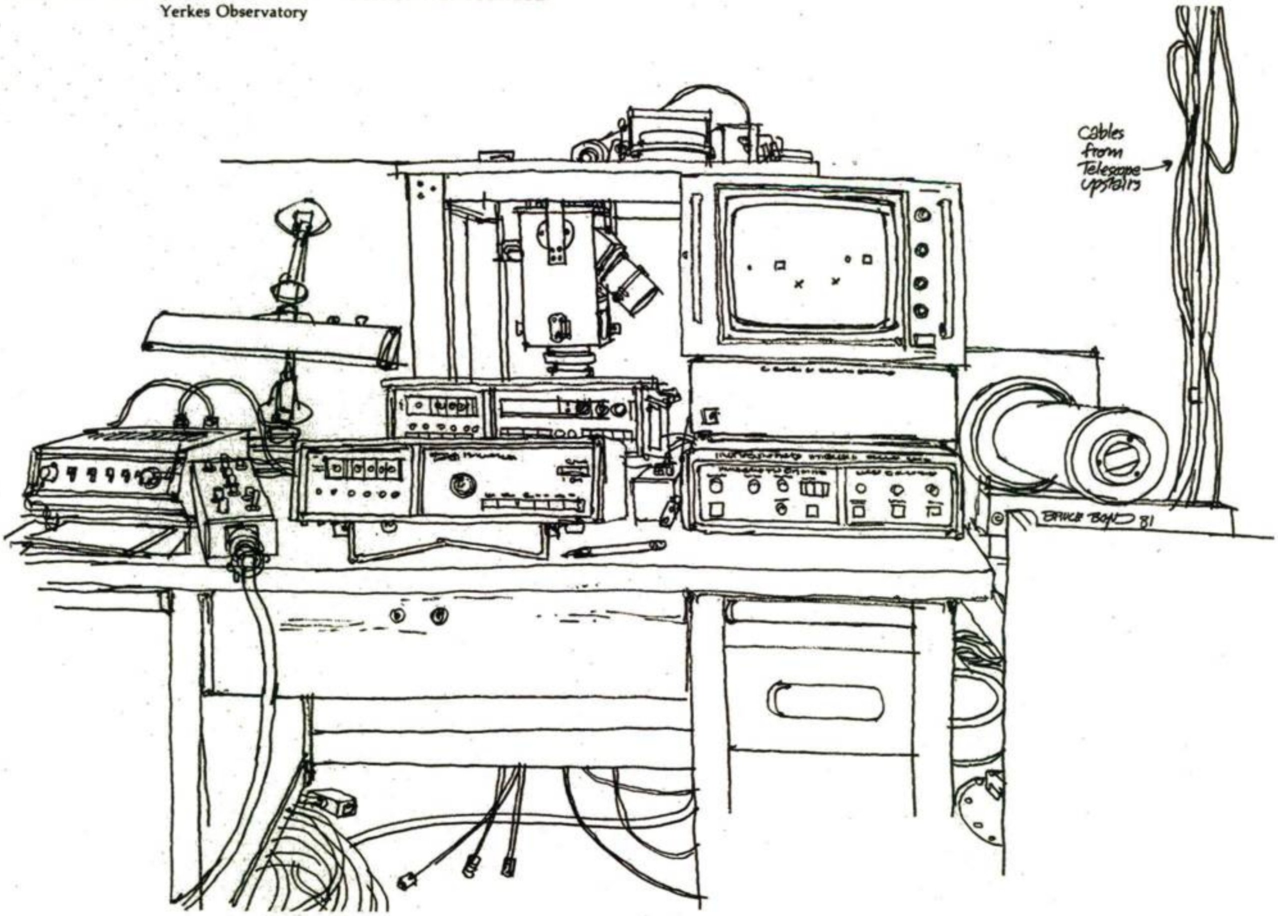
Where to locate the observatory had been the subject of a great deal of research. Dark skies were essential, which meant placing it away from the lights of Chicago. But just as important was access to the university, located in the city. Finally, the figure of 100 miles' distance was chosen as being the maximum practical limit.

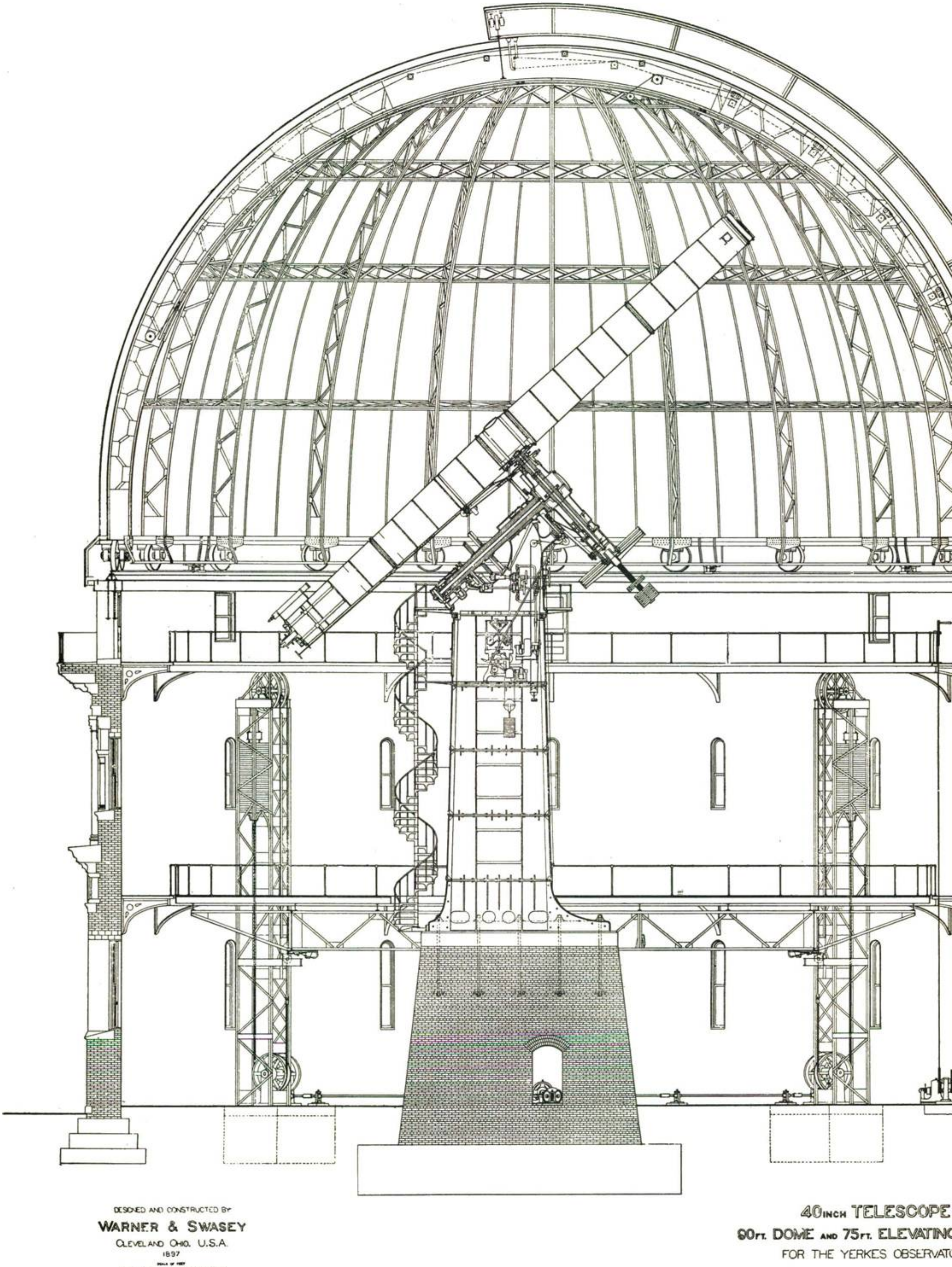


Yerkes Observatory

Left: A view from the apex of the 40-inch dome down onto the pier and framework of the rising floor.

Below: Racks of electronics symbolize many of the advances in astronomy since Yerkes was founded.




DESIGNED AND CONSTRUCTED BY
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40INCH TELESCOPE
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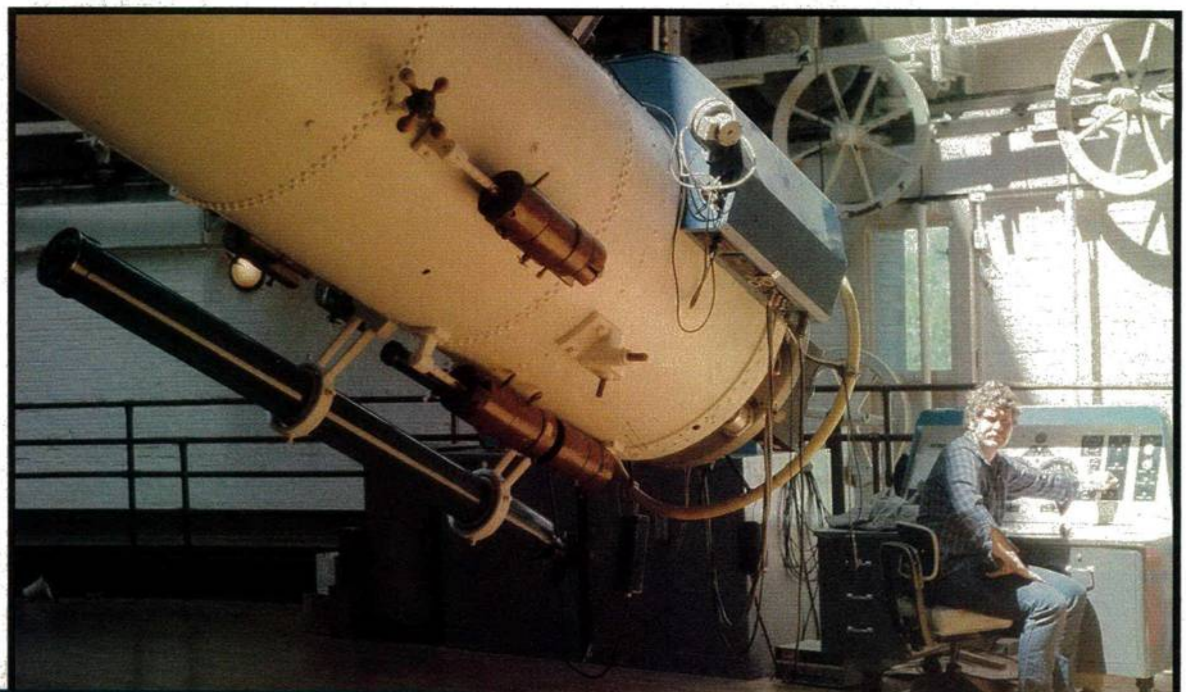
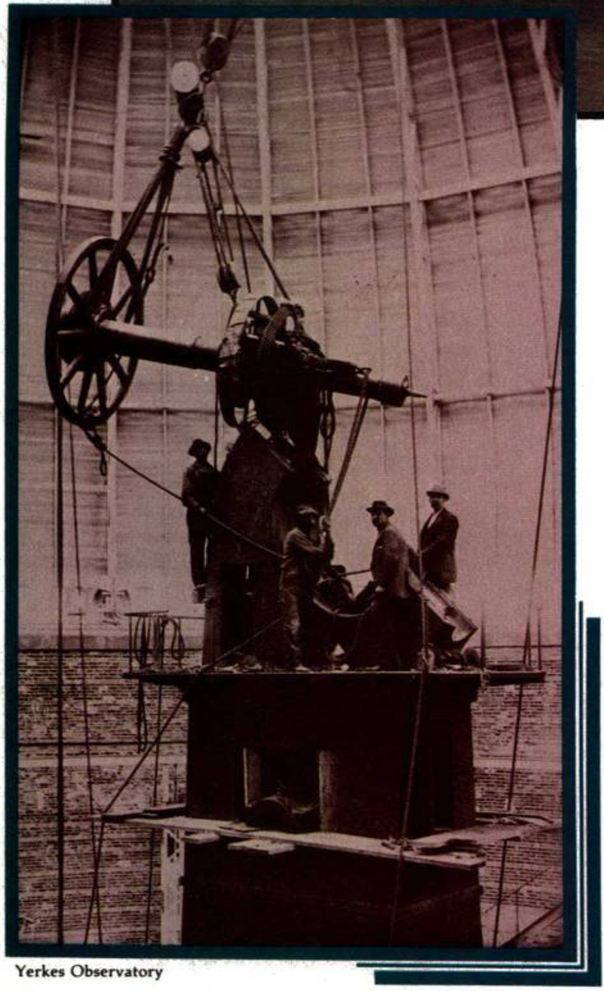
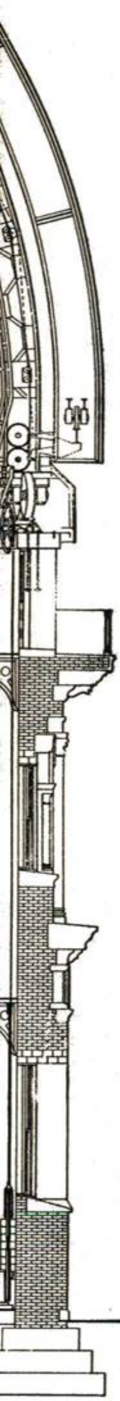




Yerkes Observatory



Top: The eyepiece end of the modernized 40-inch and its control console.

Above: Hoisting the polar axis of the 40-inch into place.

Left: The dome of the 40-inch in cutaway.

Hale circulated a list of considerations that might affect the location of the great telescope among nine top American astronomers. Their responses led Hale to favor a 53-acre tract at Williams Bay on Lake Geneva in Wisconsin, 76 miles from Chicago. The site included 500 feet of frontage on the lake itself, and had ample sand and gravel to form a vibration-free foundation for the footings of the telescope. Professor Sherburne W. Burnham's opinion that the Yerkes Observatory might be established at Lake Geneva "without fear of local atmospheric disturbance" was accepted as final, and Hale's recommendation was confirmed by the university.

Construction began in 1895. The building is a long, relatively narrow structure that runs east-west. At the eastern end is a "cross-bar" with two small domes and, extending beyond, a small meridian transit room; the great dome for the 40-inch crowns the western end. The exterior finish of the Romanesque-style building is brown brick with elaborately-carved decorative stonework.

Before construction of the building began, the Warner & Swasey Company of Cleveland had been at work on the design and construction of the tube and mounting. These were completed in time to be displayed at the World's Columbian Exposition in Chicago in 1893.

Warner & Swasey was also responsible for designing the 90-foot dome and the 75-foot diameter rising floor. Since the eyepiece end of the telescope is at various heights depending on where the telescope is pointing, a movable floor is necessary to avoid having astronomers climb an assortment of rickety ladders. The dome revolves on 26 wheels, each three feet in diameter; electric motors control the movement of the dome, rising floor, and telescope.

The 40-inch refractor is the largest ever

"If I mistake not the signs of the times, the Yerkes Observatory can render no better service to both astronomy and physics than to contribute . . . toward strengthening the good will and the common interest which are ever tending to draw astronomers and physicists into closer touch."

George Hale, at the Yerkes dedication, October 21, 1897

completed, a gain of 4 inches in aperture and 23% in light grasp over the Lick telescope on Mt. Hamilton in California. The Clark firm required nearly 5 years to grind and polish the blank disks into the two-element crown and flint lenses that combine to form the 40-inch objective lens.

In early May of 1897, the lenses were brought to Williams Bay in a private railroad car accompanied by Alvan G. Clark and Carl Lundin, the chief optical foreman. They supervised the installation of the objective in its cell and attached it to the telescope.

The first observations were made on the evening of May 21, after a frustrating spell of cloudy weather. "Such objects as the Ring Nebula in Lyra, the great cluster in Hercules, and the Dumbbell Nebula are shown in a surprising way. The brightness of these objects in the telescope is remarkable, and it is already clear that no other instrument in the world will show nebulae in so perfect a manner," wrote Hale to Yerkes.

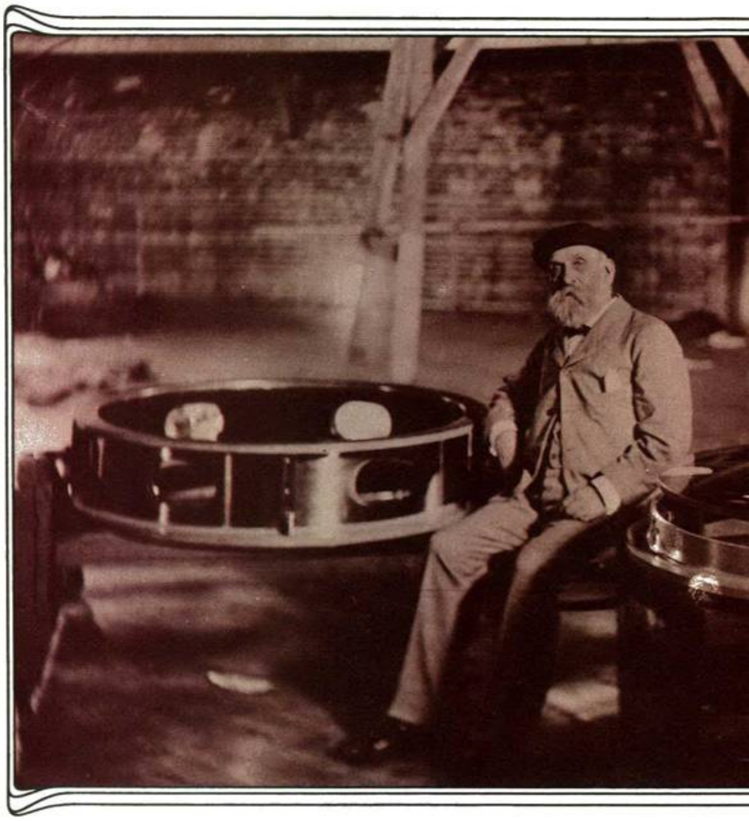
Additional proof of the excellence of the objective came when E.E. Barnard discovered a faint third companion to Vega, which had gone undetected even by the skilled observer Sherburne W. Burnham using the 36-inch Lick telescope.

Hale: "The discovery of such an object is a very severe test of the performance of the object glass. It shows that its polish must be very perfect in order that the field of view shall not be so brightly illuminated by Vega as to completely conceal any faint objects in its neighborhood. It shows too that the definition of the object glass must be very good; for if the feeble light of the star were not brought sharply to a distant focus it would be too faint to be visible. And finally, it demonstrates the great light-gathering power of the instrument and leaves no question that the Yerkes telescope is not only the largest, but also the most powerful in the world."

Test observations continued until the night of May 29. Early that evening, Hale worked with the 40-inch; then at 12:45 a.m., Frederick Ellerman and Barnard began observations of the Swan Nebula in Sagittarius. During these observations, Ellerman noted a strange noise when he raised the floor, but couldn't find the cause. By 3:15 a.m., with their work completed, he and Barnard closed the dome and left.

At 6:45 a.m., the contractor, J.C. McGee, was on his way to the observatory when he heard a shattering, splintering crash. In the dome, the cables which held the counterweights had snapped, and the southern half of the rising floor had collapsed.

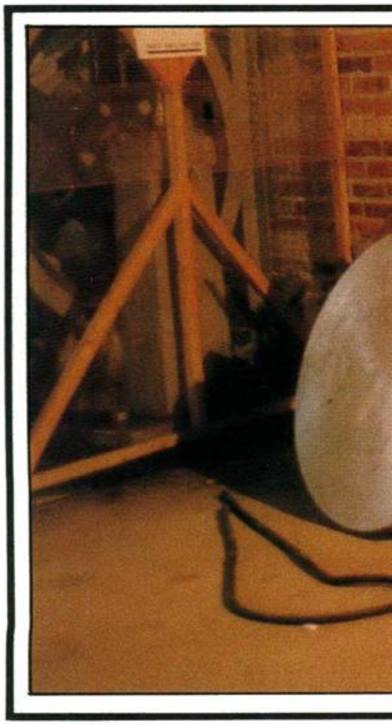
Fortunately, no one was in the dome at the time and the 40-inch itself was found to be undamaged. However, repairs took until mid-September, during which time the dome could not be moved. With characteristic energy and determination, Hale and Barnard continued to use the 40-inch, aiming it through the narrow slot in the dome.



When repairs were complete, the telescope was in use night and day. Visiting English astronomer H. H. Turner noted, "They work too hard at the Yerkes Observatory. Morning, afternoon, and night, the work seems to go on continuously . . . The center of it all is the 40-inch, which never rests. The whole performance is splendid, and strikes awe into the beholder if he happens to come from lands where

"One of the principal aims of the observatory is to bring together the physical and astronomical sides of the work. Therefore the building will be provided with laboratories for optical, spectroscopic, and chemical work, concave grating rooms, large dark rooms, a galvanometer room and a large heliostat room."

George Hale



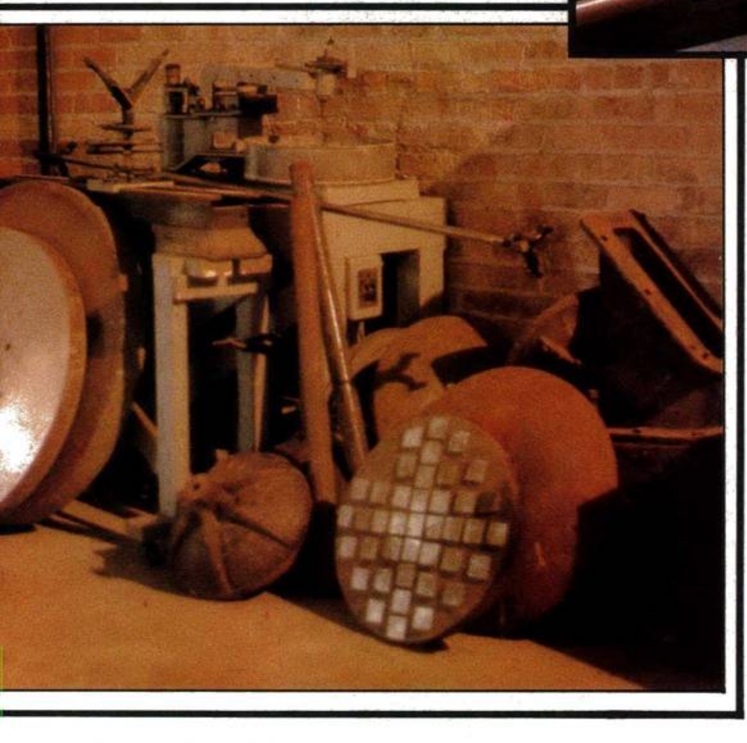
Yerkes Observatory

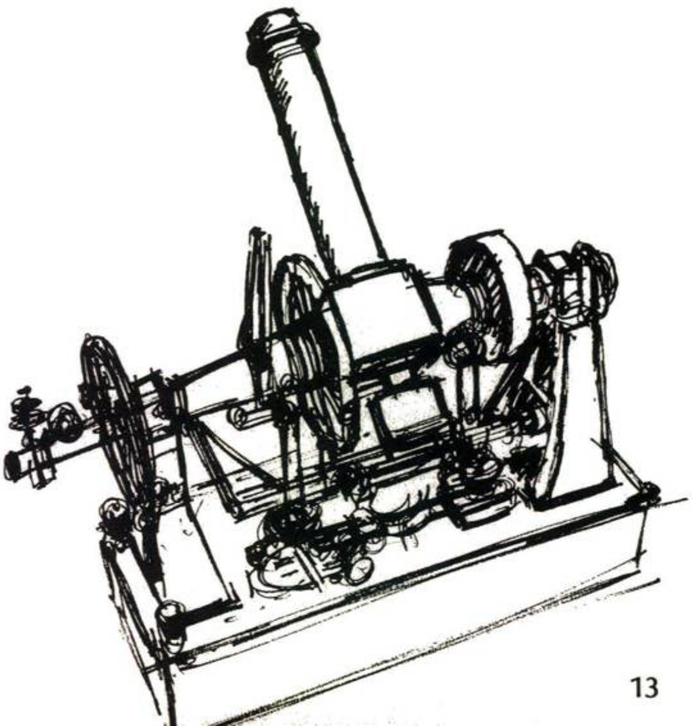
Above: Alvan G. Clark (left) and Carl Lundin with the 40-inch lens and its cell.

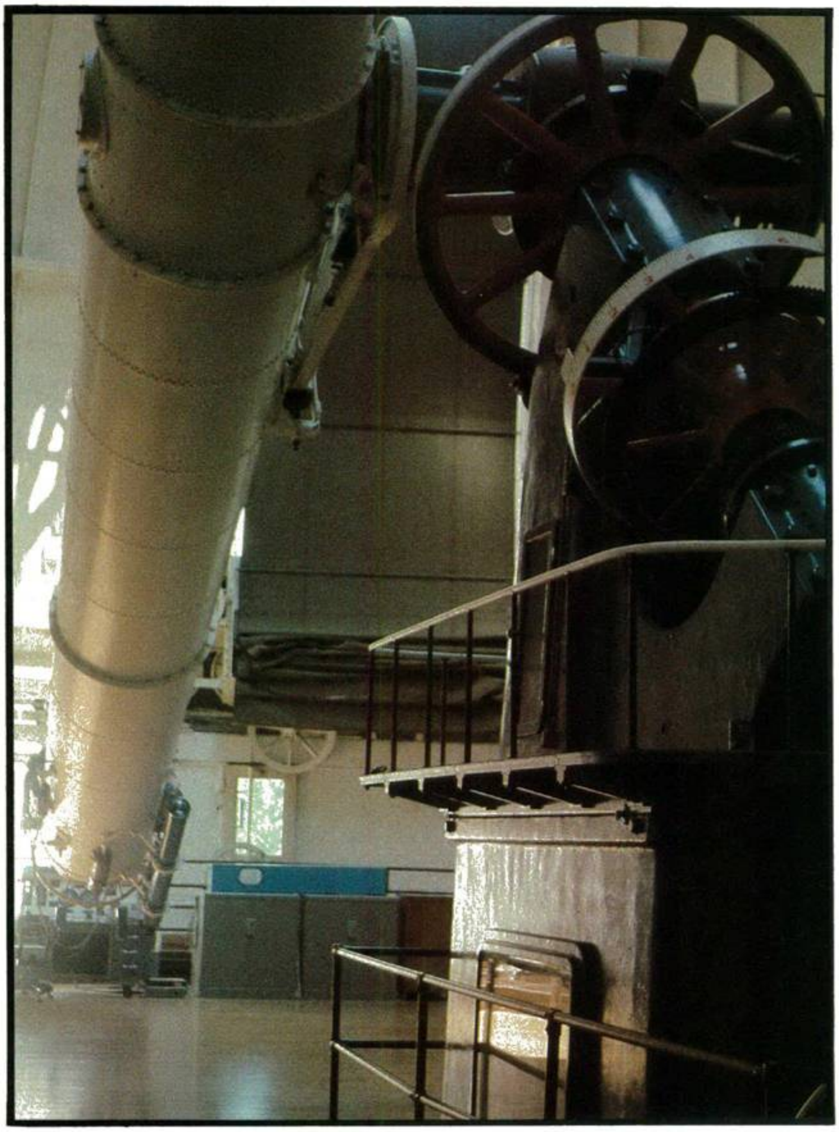
Right: Wheels and pulleys control the rising floor.

Below: Stored in the basement of the big dome are tools for the grinding and polishing of lenses and mirrors.

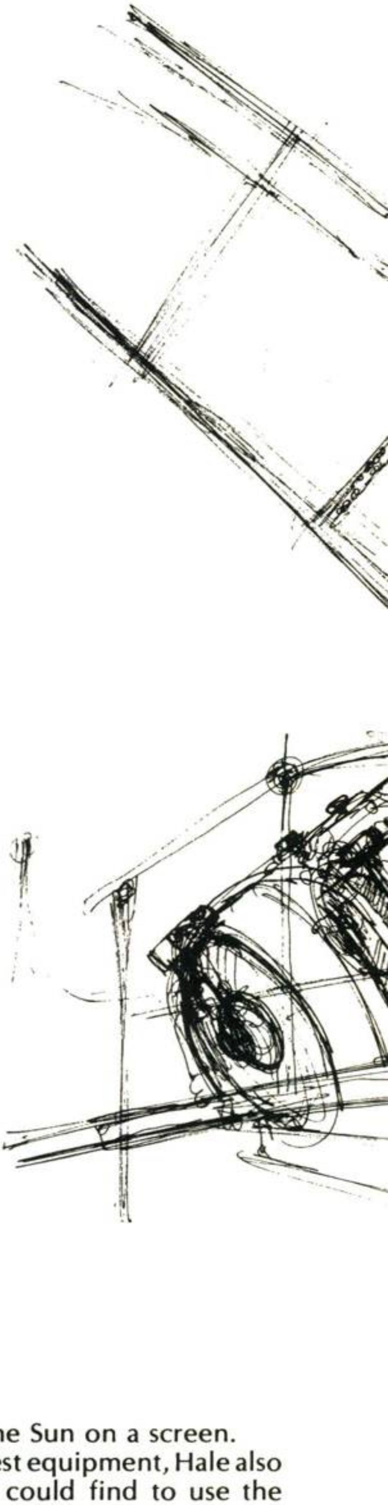
Bottom right: A small transit instrument.







Above: Looking north near the pier of the 40-inch with the floor raised almost all the way.



Right: The polar axis and drive gears of the 40-inch.

folks still retain the mistaken idea that one ought to rest now and then."

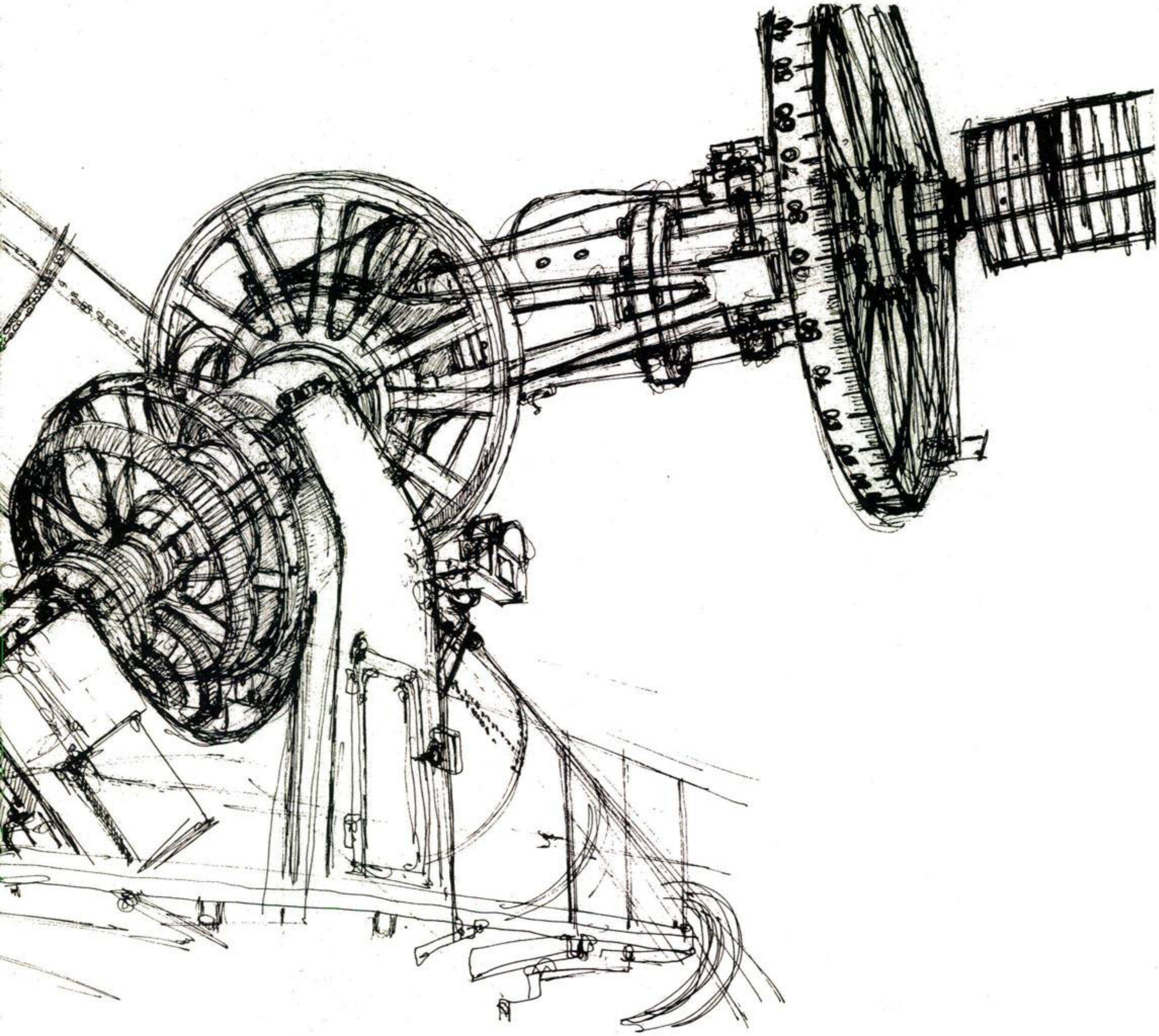
By the time of its belated dedication in October, Yerkes had become the most modern and well-equipped astrophysical observatory of its day. Hale had seen to it that the instrumentation was second to none. Equipment for the 40-inch included a stellar spectrograph and a filar micrometer, and there was a spectroheliograph under construction in the Yerkes instrument shop.

Installed in the northeast dome was the 12-inch refractor from Hale's Kenwood Observatory, outfitted with objectives color-corrected for both visual and photographic work, a spectroheliograph, and several other attachments. The transit instrument and chronometers in the meridian room determined the observatory's position to be 42° 34′ 12.64″ north latitude and 5h 54m 13.24s west longitude.

A new 24-inch aperture silver-on-glass reflector built by George Ritchey went in the southeast dome. This excellent instrument was to be used with great success for 60 years and served as a prototype for many modern reflectors, including the 200-inch on Mt. Palomar. In the attic between the two smaller domes was a heliostat room, 104 feet long and 21 feet wide. A movable iron roof allowed sunlight from the heliostat mirror to pass through a set of optics and form an enlarged image of the Sun on a screen.

Besides gathering the finest equipment, Hale also assembled the best staff he could find to use the instruments to their fullest. Able, energetic, and enthusiastic, these people were aware that they had been given a superb tool for unlocking the secrets of the universe — and lost no opportunity to make the most of it.

Foremost among the observers was Edward Emerson Barnard. Born in Tennesee in 1857, Barnard was self-taught in astronomy. He had had a distinguished career at Lick Observatory before Hale lured him to Yerkes. Throughout a long lifetime he continued to be a most active and productive observer, logging more time at the eyepiece than any other astronomer before or since. When visitors to



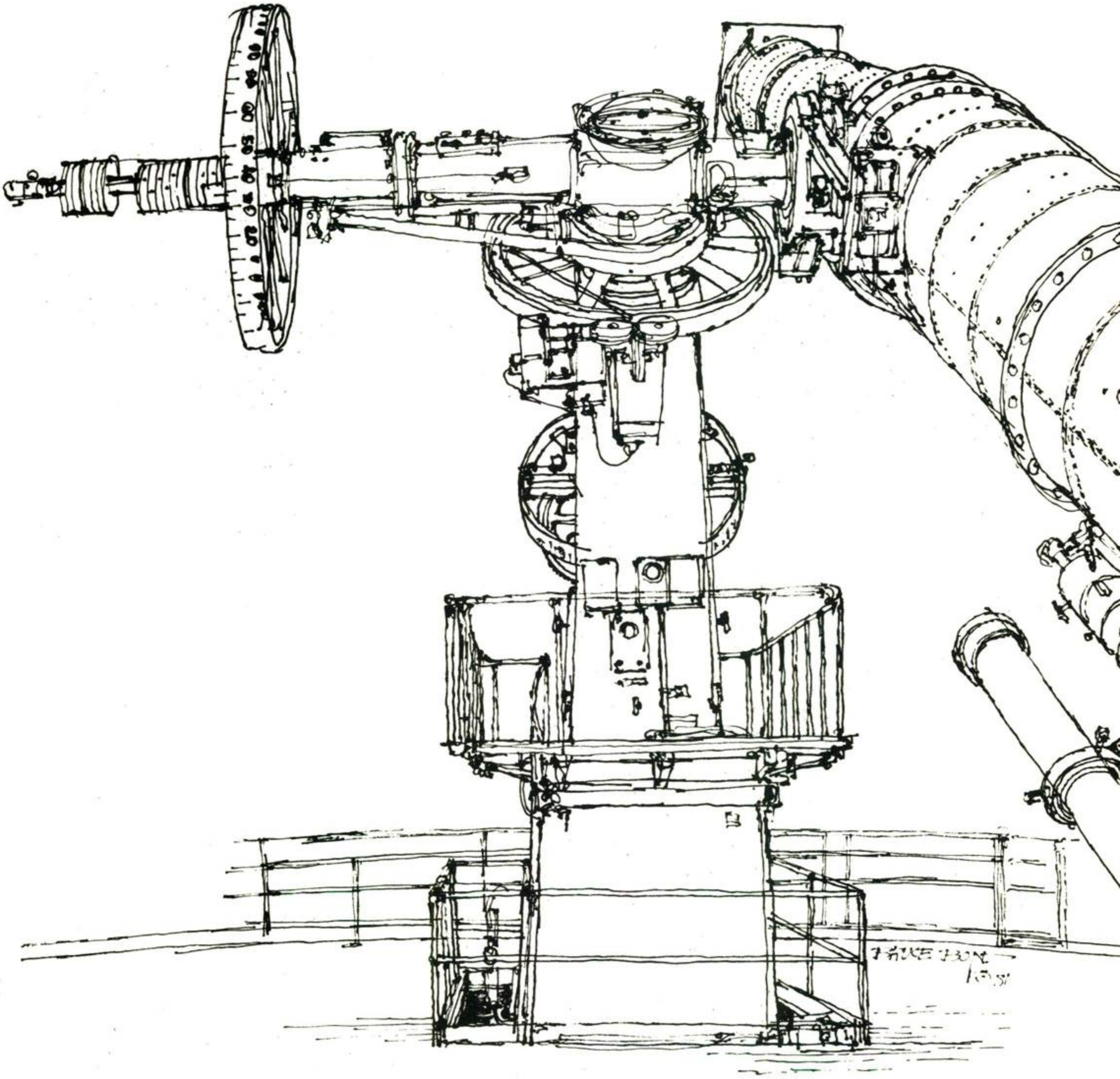
the observatory asked him how observers kept warm in the -20° cold of Wisconsin winters, he baldly replied, "We don't."

Nor were all his achievements made visually. Utilizing a special fast photographic lens, Barnard took photographs that were compiled into the beautiful *Photographic Atlas of Selected Regions of the Milky Way*, a work that remains a landmark in the study of our Galaxy.

Among the other observers, Sherburne W. Burnham continued his work, begun at Lick, in cataloging double stars. With the 40-inch, he was able to measure thousands of neglected and overlooked pairs, adding precious data to the meager store of information on stellar masses. In 1906, with Hale's support, Burnham was able to publish his *General Catalogue of Double Stars within 121° of the North Pole*. This great catalog contains data on 13,665 double and multiple star systems and gave a tremendous boost to double and multiple star astronomy.

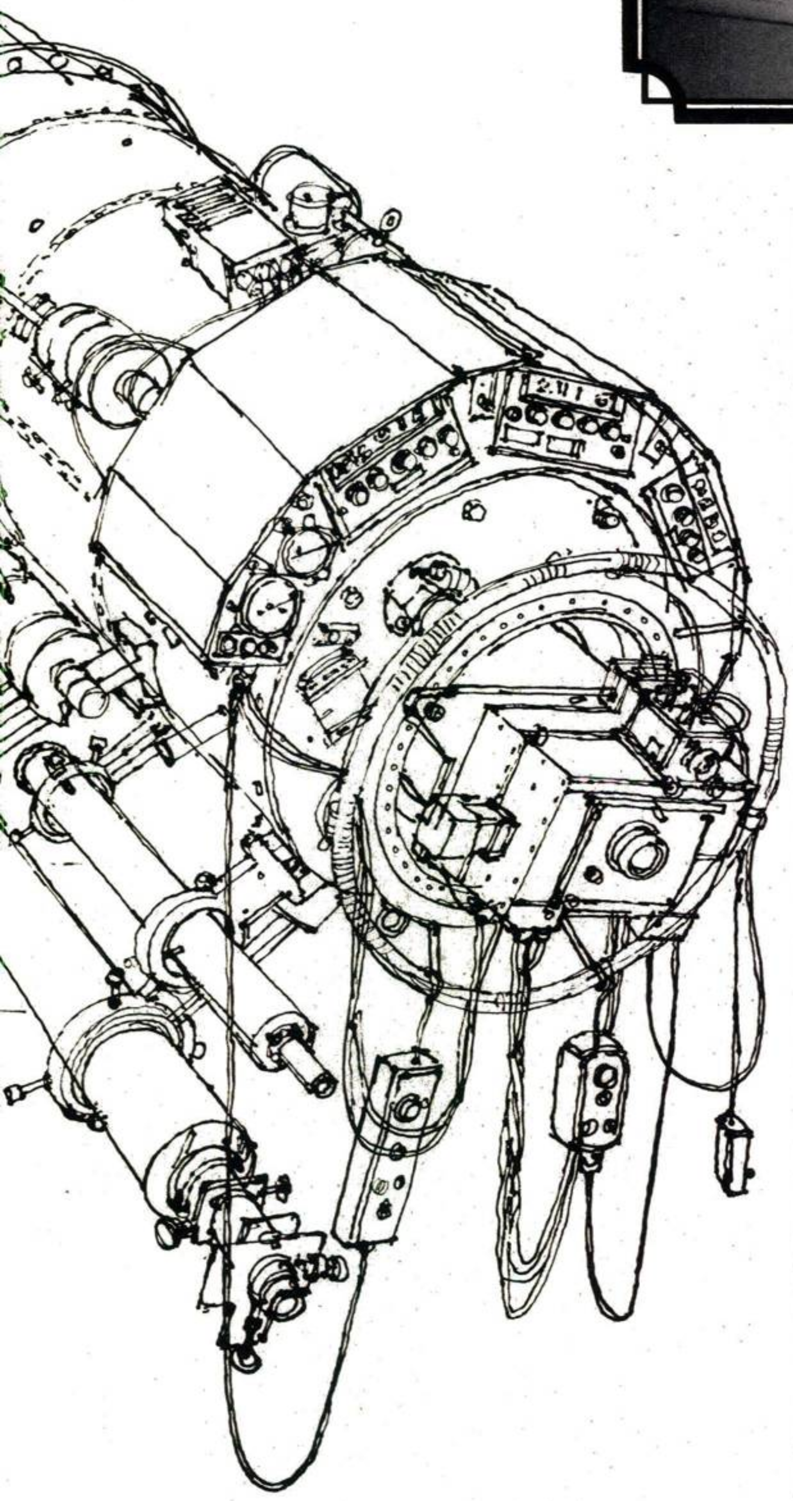
Hale, Ellerman, and John Parkhurst studied the spectra of cool stars. Although Hale's chief research interest was in the realm of solar physics, he also developed many long-range comprehensive plans of research, including both positional and astrophysical astronomy.

In 1899 Hale's spectroheliograph was completed in the Yerkes instrument shop; with it, he proved that the dark calcium and hydrogen flocculi seen on the solar disk were vast prominences thrown off by activity in the Sun's outermost layers.



"The Yerkes Observatory was conceived as something vastly larger and more important than even a first-rank astronomy department of a large university. It was meant to provide for the Middle West what the combined resources of Harvard, Yale, and Princeton provided for the East and what Lick and, later, Mount Wilson provided for the West Coast."

Otto Struve, Yerkes Director



Left: The 40-inch pointing at the meridian. To maintain rigidity, the tube tapers from its middle toward each end.

Right: Instruments of yesteryear.

Ernest Nichols arrived in the summer of 1898 with a radiometer to determine the heat from stars. Mounted in the heliostat room, the device successfully measured the near-infrared radiation of Arcturus and Vega. Spectroscopist Walter Adams, who was to become one of Hale's closest associates, also joined the staff in 1898. He and Edwin Frost measured the radial velocities of B-type stars.

Albert Michelson continued experiments at Yerkes, where he measured double stars with his interferometer. Frank Schlesinger pioneered the photographic determination of stellar parallax, increasing by a factor of 10 the accuracy of distance measurements over those made by visual observations.

Among the other prominent staff members were optician Frank Ross, who introduced a wide-angle lens that for many years was an important photographic tool. George Ritchey, another Yerkes optical designer, demonstrated how the visually color-corrected 40-inch could be used photographically as well by placing a yellow filter in front of a special photographic plate. He also made a 24-inch reflector mirror and figured a 60-inch mirror which was later used at Mt. Wilson Observatory.

But marvelous as it was, Yerkes wasn't ideal for all types of observations. Hale gradually became dissatisfied with the lack of consistently clear and steady skies for his solar work, and was increasingly aware that some of the most important problems in astrophysics needed more aperture than 40 inches. Checking on alternate sites, Hale spent the winter of 1903-1904 in California at Mt. Wilson. Satisfied that it was ideal for both solar work as well as large-aperture telescope observations, Hale returned to Yerkes and persuaded many able members of the staff to go west with him. Among those joining the new Mt. Wilson Observatory were Adams, Ellerman, Ritchey, and Francis Pease; the horizontal solar telescope and the unfinished 60-inch mirror went too. Edwin Frost became director of Yerkes.

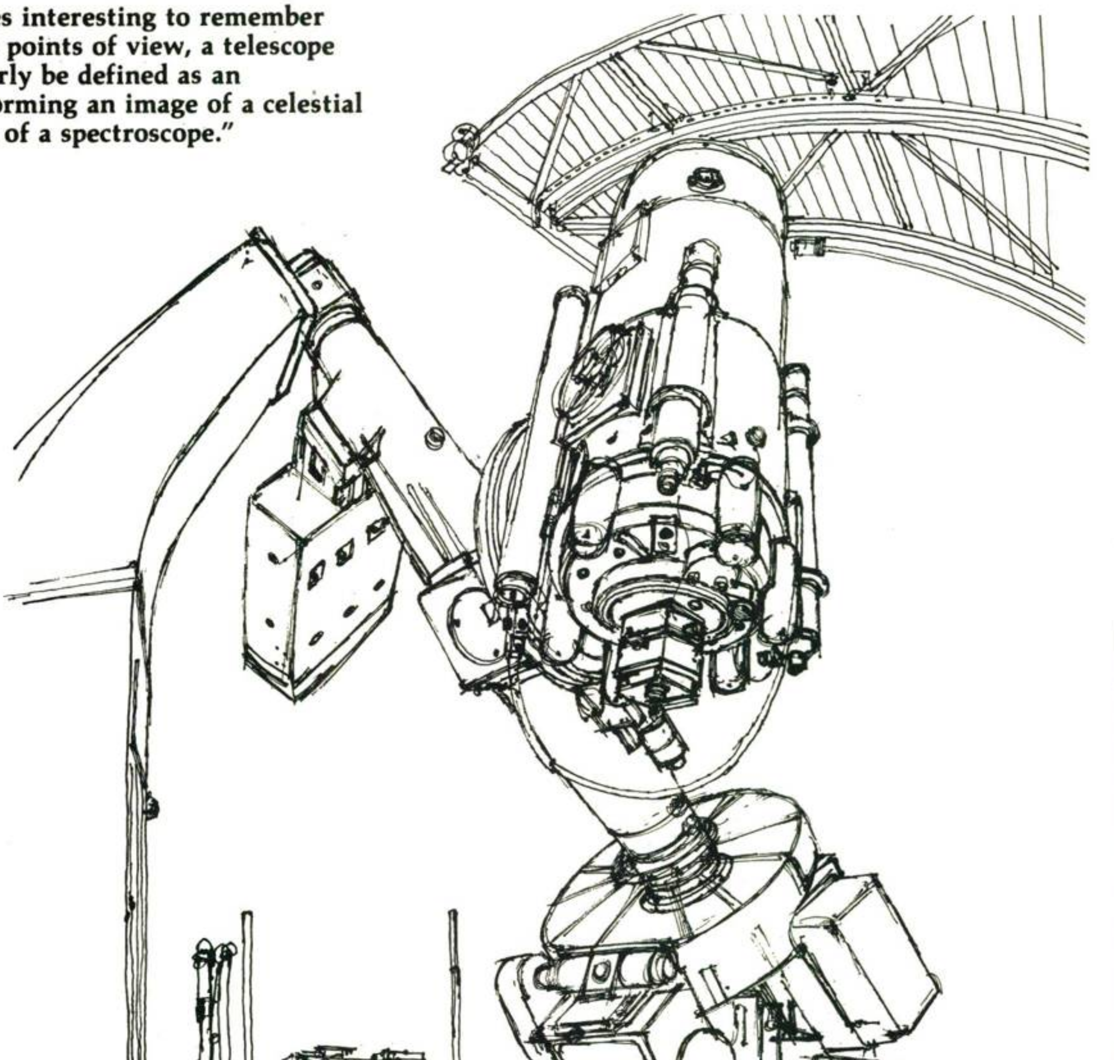
Even with the disruption of Hale's departure, many pioneering programs continued. Yerkes still attracted astronomers and physicists of the first order. George van Biesbroeck began a program of positional observations of comets and asteroids with the 24-inch reflector. Parkhurst worked to perfect photometric scales of stellar magnitudes. Barnard contined to observe virtually everything that could be measured with a micrometer or photographed on a plate.

During 1913, Edwin Hubble worked with Ritchey's 24-inch reflector, photographing faint galaxies — a field of research that was later to make him famous when, using the Mt. Wilson 100-inch telescope, he was the first to find Cepheid variable stars in the Andromeda galaxy and determine its distance. In 1924, Frank Ross's work in photography began to reveal the faint features of interstellar matter in the Galaxy.

Otto Struve, whose father and grandfather had each been director of the Pulkovo Observatory in Russia, came to Yerkes as a graduate student in this period. Eventually appointed to the faculty, Struve replaced Frost as director in 1932 and held that position until 1950. Struve was a superb spectroscopist and made detailed studies of stellar atmospheres,

"It is sometimes interesting to remember that from certain points of view, a telescope may not improperly be defined as an instrument for forming an image of a celestial object on the slit of a spectroscope."

George Hale



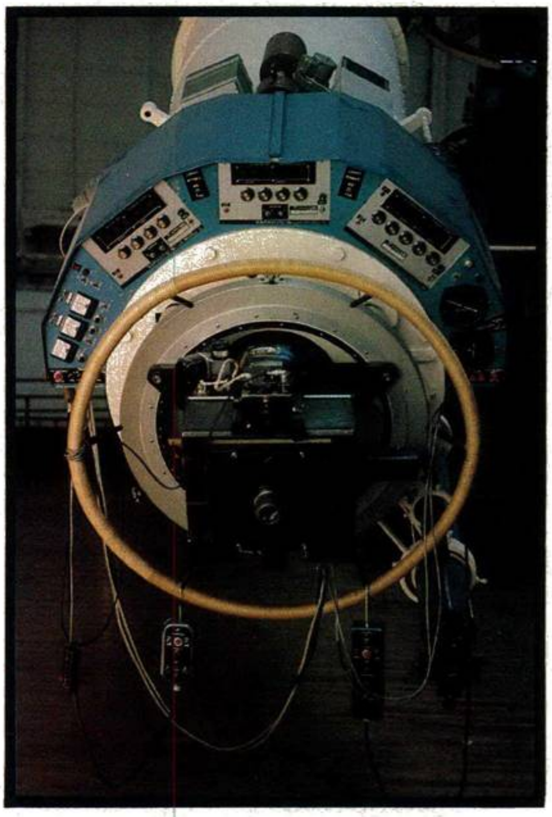
stellar rotation, and binary stars. W.W. Morgan, a 1931 graduate, determined the distances and luminosities of stars from their spectra. His work greatly increased our knowledge of the shape of the Milky Way Galaxy we live in.

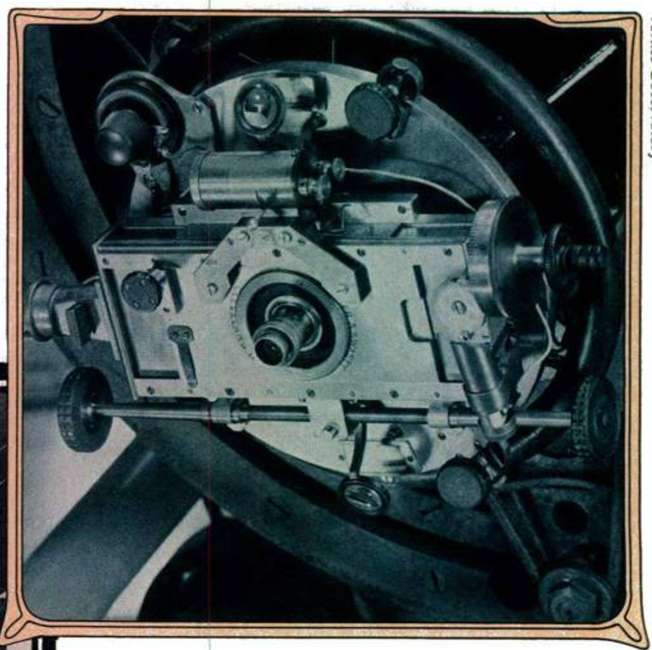
By the early 1930s, the advantages of climate in the southwestern part of the country led the University of Chicago and the University of Texas to agree on the construction and operation of a new observatory in western Texas, the McDonald Observatory. The agreement is still in effect; currently, about 10% of the observing time on the McDonald 107-inch reflector is allocated to users from the University of Chicago.

Yerkes continues to be an integral and essential part of the university. The Department of Astronomy and Astrophysics has 16 faculty members, of whom about a third live at Yerkes. Their research interests span nearly the full spectrum of modern astronomy, and the resulting discoveries range from observational studies of the most distant known galaxies to theoretical investigations of black holes.

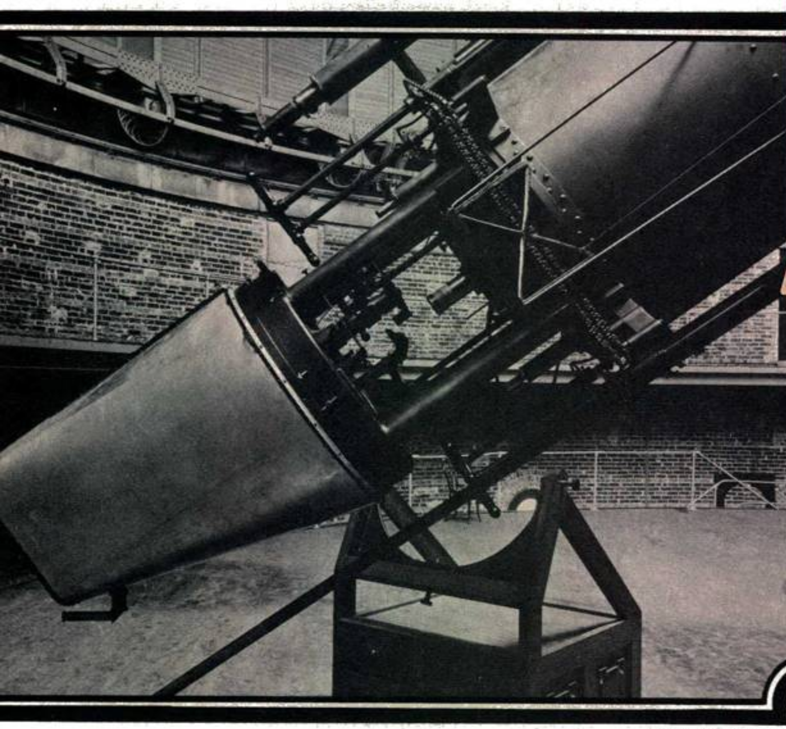
Today, the visitor who takes advantage of the observatory's open hours (Saturday mornings, October 1 through May 31; Saturday afternoons, June 1 through September 30) approaches Yerkes along a lengthy avenue of trees, through which the Romanesque building gradually reveals itself. In many ways the structure has grown more elegant under its patina of years. The bare, muddy fields that surrounded it in 1897 are gone, replaced with mature trees and the sculptured landscaping that Edwin Frost supervised. His sense of order, harmony, and dignity are very much in keeping with the character of the place.

Inside, the changes of the years are just as apparent: the massive 40-inch refractor remains the largest such instrument in the world, with a light-gathering power 35,000 times greater than the





Yerkes Observatory



Yerkes Observatory

Top: A camera on the 40-inch.

Above: The filar micrometer is used to measure the separation of double stars.

Far left: The modern 41-inch reflector.

Left: The Bruce spectrograph on the 40-inch.

unaided eye and an angular resolution of about a tenth of a second of arc.

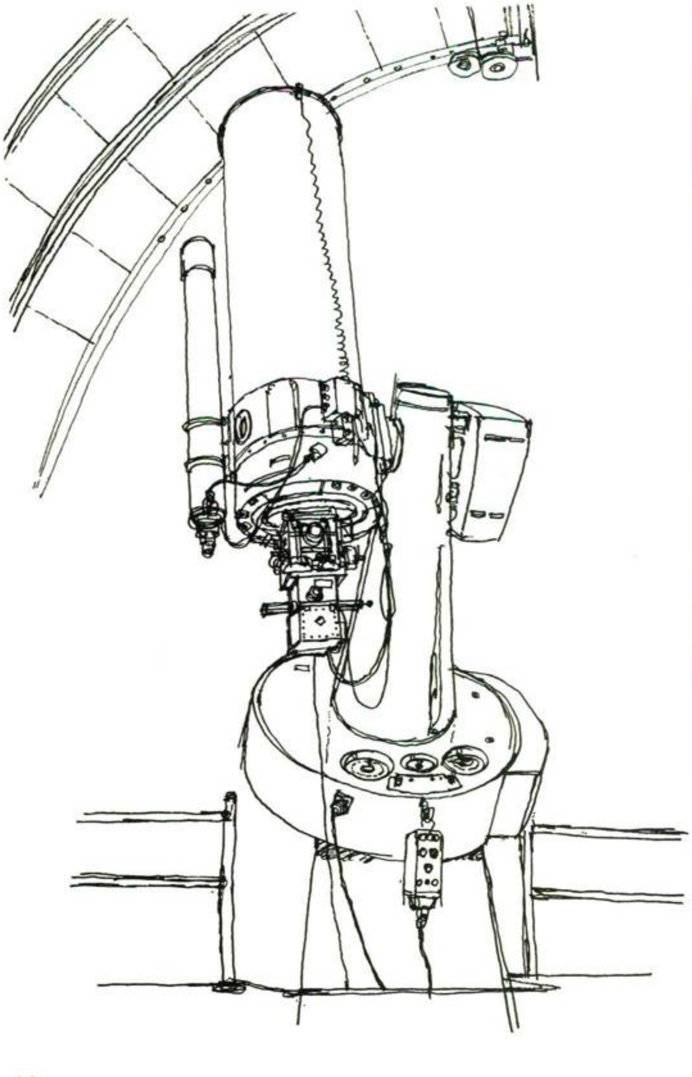
But no longer must observers squint and peer at the equatorial to tell where the instrument is pointing. Electric motors with digital readouts indicate the direction and make for rapid, smooth and accurate setting on objects. The primary use of the 40-inch now is in accurate determinations of the motions and distances of stars. Because of its great focal length, this telescope is perhaps the world's best for these tasks.

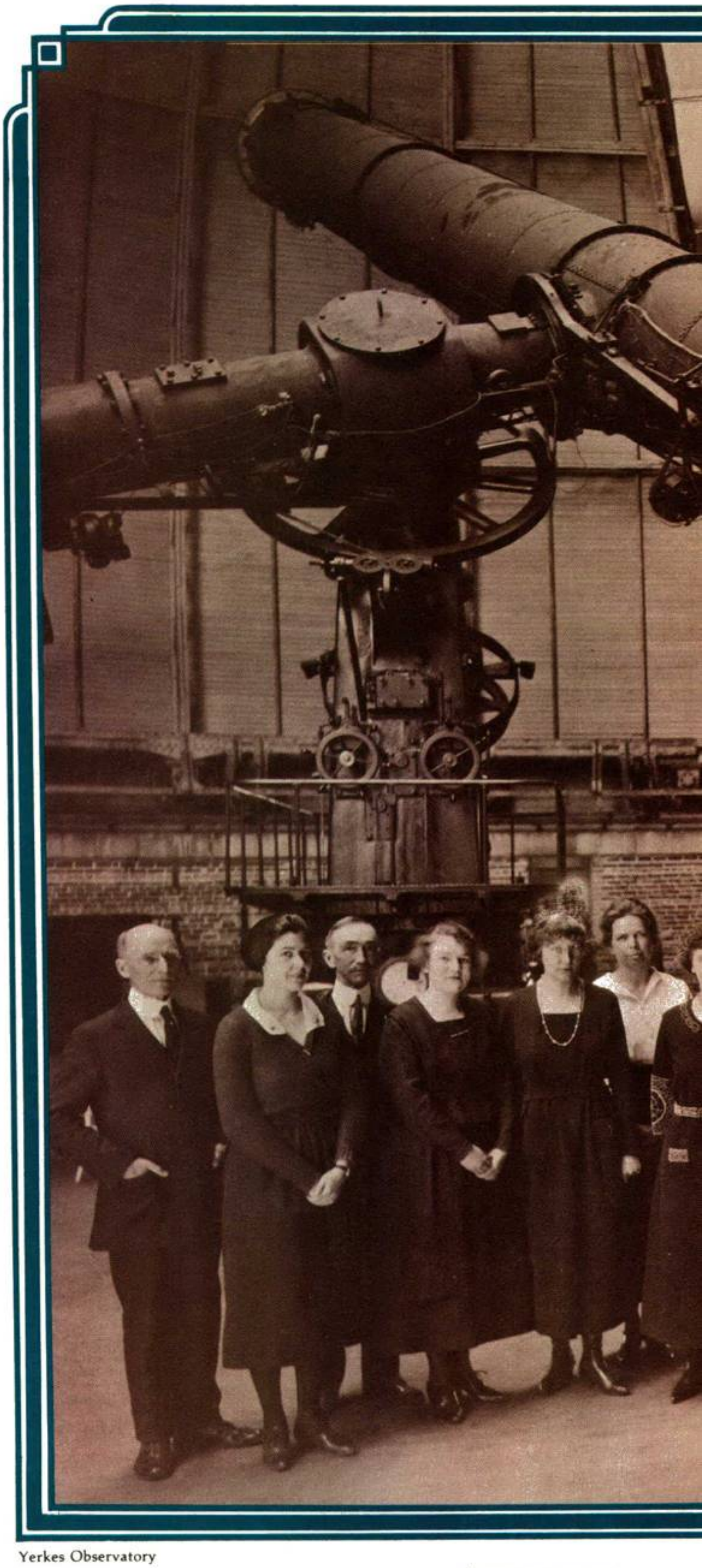
The 24-inch in the southeast dome has been replaced with a 41-inch reflector that became operational in 1968. It is equipped for image-intensifier-assisted spectroscopy and photography, photoelectric photometry, and high-resolution interferometric spectroscopy. Hale's 12-inch refractor from his old Kenwood Observatory has been replaced with a new 24-inch reflector. This entire telescope, including mirrors, can be rotated on its optical axis, allowing greater precision in measuring the polarization of starlight.

George Hale's original concept of the complete astrophysical laboratory has continued over the years, and the Yerkes building houses mechanical and electronic workshops, several instrument labs, darkrooms, a computer room, and a climate-controlled plate vault.

In contrast to the flashing digital electronics of the domes is the serene dignity of the library and reading room. Floor-to-ceiling bookcases, lined with volumes of many colors and textures, and high windows overlooking the peaceful landscape counterpoint today's pace with that of a quieter era.

Contrasts that add to the charm of Yerkes are everywhere: Oak, marble, brass, and tawny Roman brick with terra-cotta carvings merge with plastic,



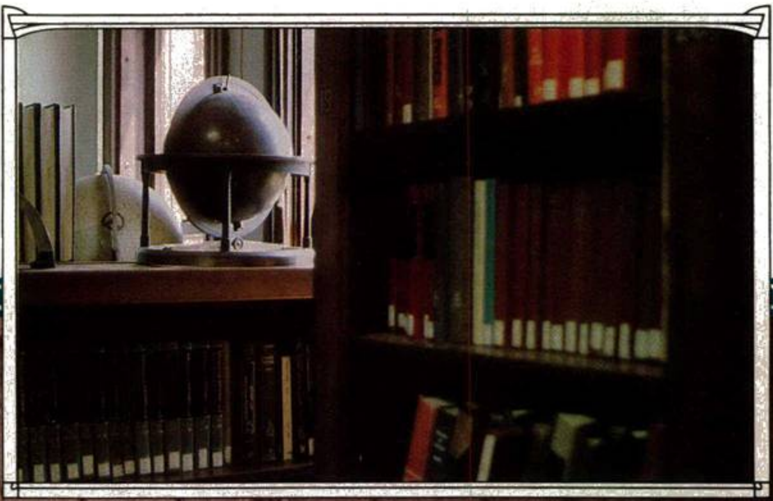


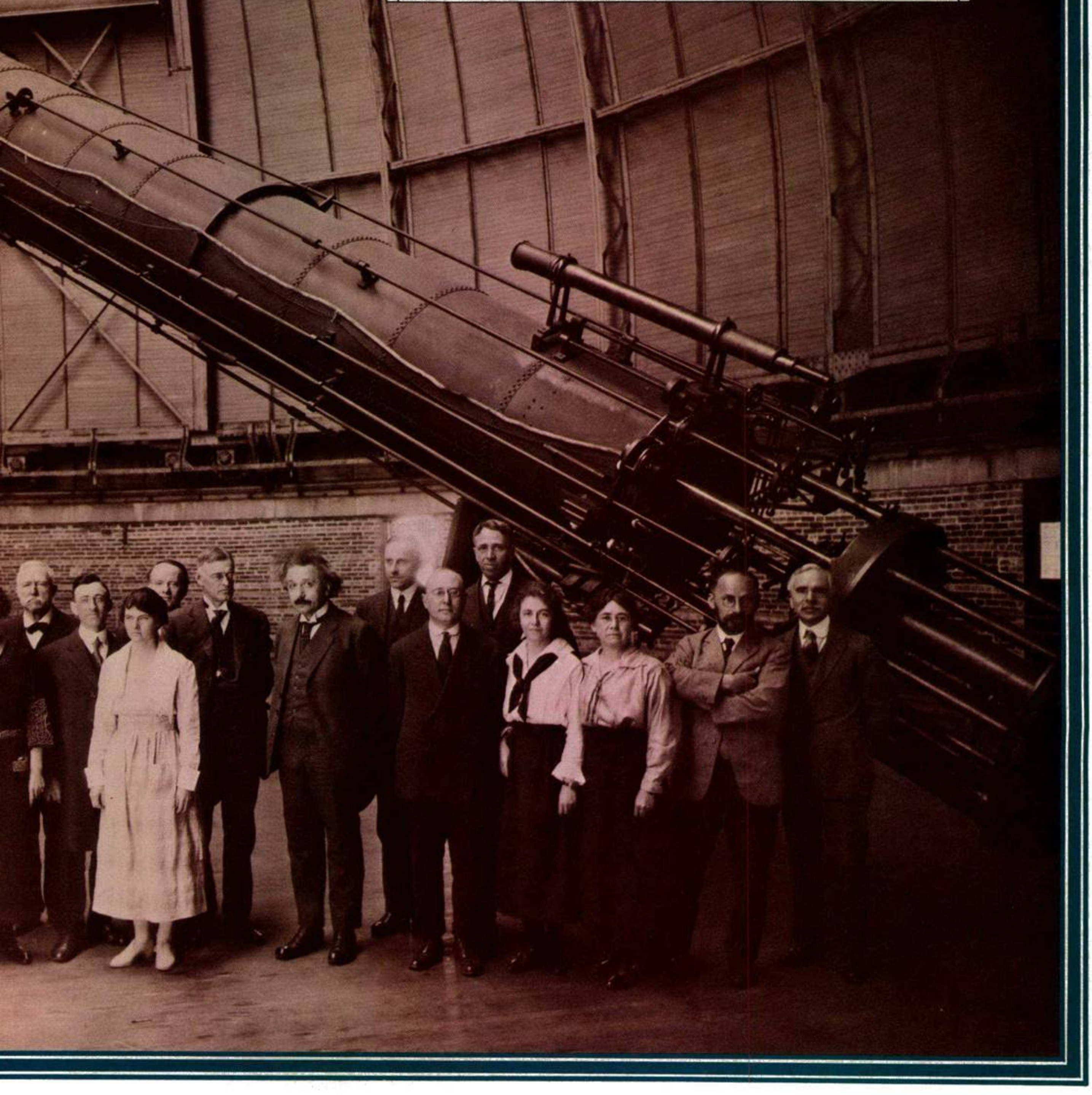
Yerkes Observatory

Right: The library.

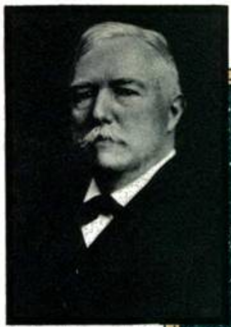
Below left: The 24-inch reflector is used primarily for polarimetry.

Below: During a trip to the U.S. in 1921, Albert Einstein visited Yerkes and posed in the dome of the 40-inch with members of the observatory staff.





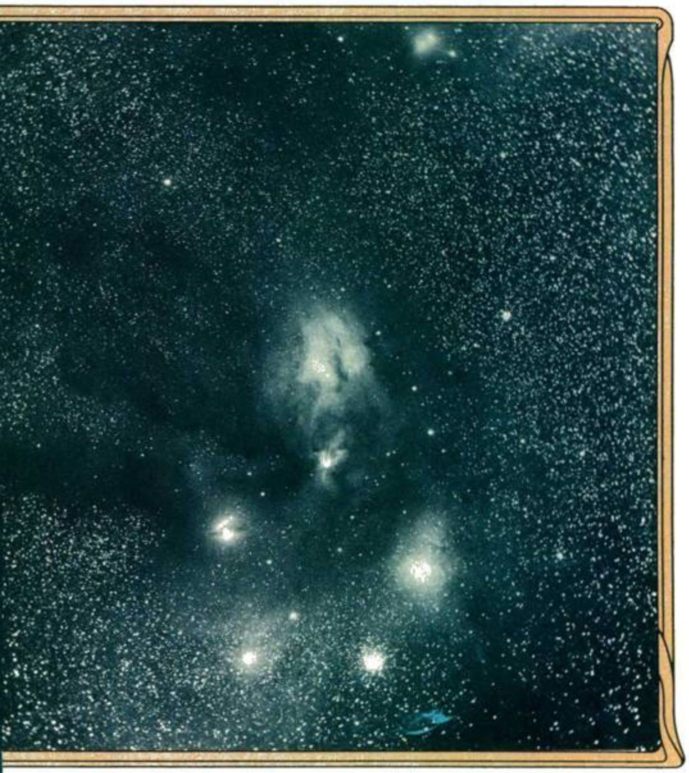
E.E. Barnard



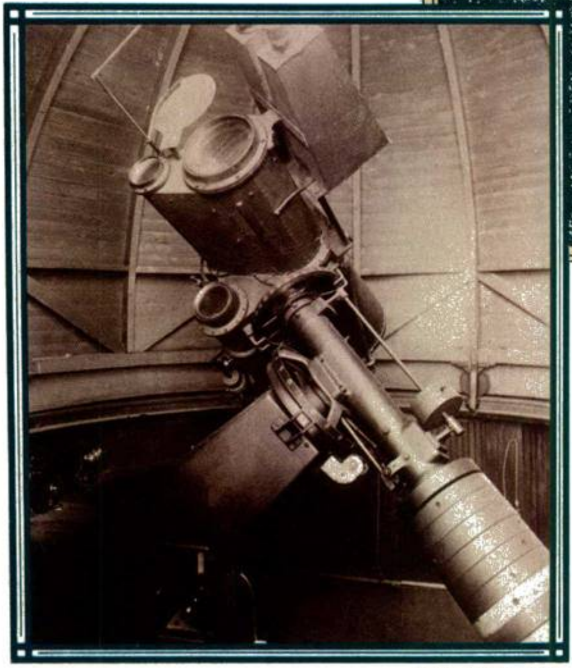
Yerkes Observatory

Right: Gas and dust in the region of Rho Ophiuchi, photographed by Barnard.

Below: The Bruce astrograph that Barnard used for his survey of the Milky Way.



Yerkes Observatory



Yerkes Observatory

acrylic, and stainless steel. Inside the night-darkened dome of the 40-inch, the polished wooden floor reflects red digital readouts mounted on the great refractor, while it silently tracks the same stars it has followed for 85 years.

As in a cathedral, there is a feeling of time and mystery within. In company with the stars and the soft keening of the wind, you sense the presence of the multitudes of astronomers who have cherished this place and its purpose.

Let the last words be Hale's: "[An astronomer's] dreams run far ahead of his accomplishments, and his work of today is part of a plan projected years ago. He perceives that only a few generations hence many of the intruments and methods of his time are to be replaced by better ones, and he strains his vision to obtain some glimpse, imperfect though it be, into the obscurities of the future."

The author is grateful to the present director of Yerkes, Dr. Lewis Hobbs, and to his staff for the many ways they helped him in researching this article.

Bruce Bond is an artist and amateur historian of astronomy. He is particularly interested in biographies of past astronomers and the instruments they used. He has written book reviews for ASTRONOMY and illustrated several articles, among them "Of Transits and Timeballs" which appeared in the December 1980 issue.

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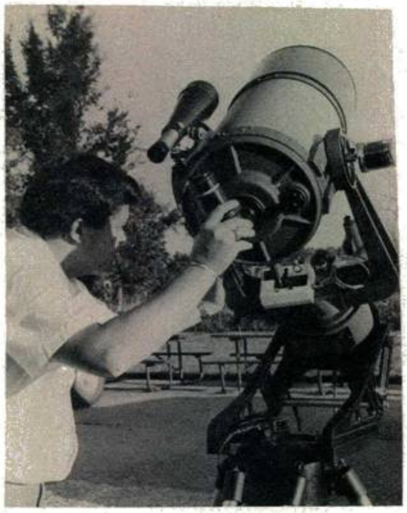

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ASTRONOMY FORUM

A Role for the Amateur Astronomer

Although it still isn't widely known or appreciated, amateur astronomers regularly obtain photoelectric photometry comparable in accuracy to that of professionals. Thus we join Jo-Ann Pluciennik (see ASTRONOMY Forum, August 1982) in disagreeing with J. Derral Mulholland's statement that "Today, an amateur astronomer is one who does trivial astronomy in his spare time and with equipment that is not normally suitable for serious research." Certainly in photoelectric photometry of variable stars, the area we are most familiar with, observations made by amateurs are neither trivial, nor should the equipment be termed not "suited for serious research."

Proof of this appears in the scores of papers amateurs have authored or co-authored in a variety of astronomy journals, including *The Astrophysical Journal, The Astronomical Journal, Astrophysics and Space Science*, and the *I.A.U. Information Bulletin on Variable Stars*. Their photometry has been responsible for the discovery of more than 20 new variable stars just in recent years, some with total amplitudes as small as 0.01 or 0.02 magnitude.

Photoelectric equipment used by amateurs today is in many cases identical to that used by professional astronomers at smaller observatories; in several cases, amateur equipment is considerably more sophisticated. Amateurs, for example, now have built equipment with automatic filter changing and sky offsetting, pulse counting, and computer data logging — features not available to professional astronomers at many observatories.

It should also be noted that there is close cooperation and collaboration between amateur and professional in the area of photoelectric photometry. An example of this is the International Amateur-Professional Photoelectric Photometry (IAPPP) association. Its 375 members come from 32 different countries and are almost evenly split between amateurs and professionals. An example of the benefit of this cooperation is the coverage of longer-period variable stars which amateurs can provide and professionals often cannot, because of the limited duration of observing runs typically scheduled at many professional observatories. Such cooperation has paid handsome scientific dividends: amateur observations of the RS CVn binaries have proven crucial in advancing scientific knowledge of these enigmatic, highly-active spotted stars.

Another relevant point is that many amateur astronomers, while unpaid (by definition!) for their work in astronomy, *are* professionals in optics, electrical engineering, or computer science. They have brought their professional skills to bear on developing low-cost photometers, pulse counters, and computerized systems which have been of considerable benefit to professional astronomers at smaller observatories. With all due respect, professional astronomers frequently have "amateur" skills when it comes to constructing photometers, designing electronic instruments, and even, sad to say, simply finding their way around the sky.

In just the last year or so, we passed a significant turning point: amateur astronomers made photoelectric observations as "guest" observers at professional observatories, where time is allotted on the basis of scientific merit. Almost simultaneously, professional astronomers have applied for observing time as "guest" observers at certain well-equipped amateur observatories.

While Mulholland's statement was obviously a well-intentioned defense of Seth Chandler, we feel it does not accurately reflect the true state of modern amateur astronomy. As has been the case for several hundred years, today's amateurs span a wide range: from the most casual stargazer, who enriches his life and those about him by observing the heavens; to the most serious observer, who obtains scientific data with the utmost rigor, using the latest computerized electronic equipment.

There is room for all types. In astronomy, perhaps more than in any other area of science, the professionals have always been kindly disposed toward the amateurs, and those amateurs who care to have always had the opportunity to do scientific research of real value alongside their professional mentors. This is good because, as has been noted more than once, there are more stars than there are astronomers.

— *Douglas S. Hall*
Vanderbilt University
and
Russell M. Genet
Fairborn Observatory

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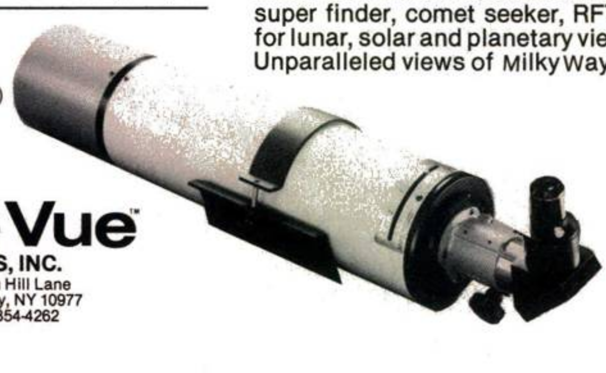

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strategies, which quickly became wrapped in religious mythologies. Sophisticated as we seem to be today, one can still see the vestiges of these origins in the role that astronomy plays in the human psyche. These folk-memories are continually renewed by the fact of universal access.

Nor is that access a trivial one. Astronomy, the most popular of sciences, is also one of the small number of sciences in which hobbyists can and do make significant and useful contributions. Those who take their hobby seriously spend much time, effort, and money in acquiring and using sophisticated equipment. They produce the bulk of certain types of astronomical observations, data of which are of great value to the researches of professional astronomers. With some exceptions, most professionals recognize and appreciate the contributions of hobbyists in such areas as monitoring the fluctuations of variable stars, timing occultations of stars by the Moon, and discovering comets and novae.

In view of the acknowledged value of hobbyist astronomy, it is a curious fact that many astronomy hobbyists do not have a secure and rational image of themselves. Some of them react violently toward any suggestion that there is a basic difference between themselves and professional — i.e., paid — astronomers. There is a difference. This does not mean (and I didn't say) that "professional" is somehow "better" than "amateur," but there *is* a difference. It is worth exploring what that difference is, and how it relates to the recent and unnecessary uproar over this question.

Part of the problem revolves about an ambiguous word that I will define and then avoid. That word is "amateur" — one of those elements of the English language that takes on different and incompatible meanings more or less at the user's whim. The *American Heritage Dictionary* variously cites "unpaid," "unskilled," and "engaged as pastime rather than profession." These are not equivalent definitions. The word "hobbyist" is unambiguous, and I use it here for clarity.

The serious hobbyist need feel inferior to no one. He frequently constructs his own equipment, which most professionals could not do if they wanted. He spends more time actually looking at the sky than does a professional. As a result, he knows the sky better, and does not fear the question many professionals dread: "What is that bright star over there?" If he participates in AAVSO, IOTA, IAPPP and perhaps other similar associations, the hobbyist submits to a discipline of structured observation qualitatively equivalent to that of the professional.

Do professional astronomers help the hobbyists? I suspect that most hobbyists do not actually know a professional astronomer personally. But I would like the hobbyists to ask themselves a few questions: Are professionals active in AAVSO? in IOTA? in IAPPP? What is their level of involvement? Do professionals contribute heavily to the most hobbyist-oriented popular magazine? Does the U.S. Naval Observatory, staffed by professionals, provide predictive services of value to hobbyists? Have some professionals (myself included) tried to promote NSF and NASA funding for some hobbyist activities?

These are but a few of the possible relevant questions.

And honesty requires hobbyists to admit that professionals do indeed involve themselves with the care and feeding of their unpaid counterparts. We do this not from condescension, but because the hobbyists do a lot of valuable astronomy. The mystery to me is that there is still the suspicion — a mythology, if you will — that professional astronomers habitually underrate hobbyists. It is simply not true.

What we do recognize, however, is that hobbyist astronomy and professional astronomy are different. Yes, some hobbyists have telescopes that would have ranked among the best in the world a century ago. Yes, some hobbyists use photoelectric gear that would have been the marvel of any observatory 30 years ago. Yes, some hobbyists can synchronize their equipment into WWV, just like the big guys.

But pay some heed to the epochs and percentages. Professionals are full-time astronomers and have large institutional budgets not available to hobbyists. It does make a difference. What hobbyist takes photographs of Chiron? Or times events routinely with microsecond resolution? Or probes into the molecules of distant galaxies? Or measures the deviations of Barnard's star? Or determines the scale and age of the Universe? Or reads, on a regular basis, the current literature in the field? You see, there are qualitative differences, because none of these things is particularly remarkable in the world of professional astronomy.

What hobbyists do is useful and valid astronomy, but it is different from the astronomy professionals do. Few professionals restrict themselves to the kinds of observations that hobbyists must. Such an astronomer would surely be denied promotion for wasting his talents and facilities. Consequently, when a true professional is cited in the popular press as an "amateur," it is an honor to his memory — and no slur on the hobbyists — to redress the error.

The hobbyist who takes offense simply is possessed of an unreasonable persecution complex. The diatribe by Ms. Pluciennik (ASTRONOMY Forum, August 1982) falls into this category. In her passion, she has distorted a phrase taken out of context from a letter that was not intended by its author for publication. She shows solidarity by referring to "a deluge of letters from irate amateur astronomers."

But she missed the point.

(If anyone cares what the point was, he should refer to Mulholland and Carter, "Seth Carlo Chandler and the Observational Origins of Geodynamics," in *High Precision Earth Rotation and Earth-Moon Dynamics*, O. Calame, ed., Dordrecht, 1982.)

However, it is an interesting sidelight that none of this deluge was addressed to me, but rather to a variety of national publications, and an inordinate percentage of the letters came from western Pennsylvania. I do not know what to make of this observation, other than that it is not *me* they are trying to convince. Maybe themselves.

The lesson that I draw from this episode is one that I knew before: many hobbyist astronomers are very defensive about what they do. Possibly that is because of the news coverage given to the more glamorous parts of professional astronomy. And more's the pity, for they needn't be. It is not even necessary to resort to the puffery of citing the exceptional cases amongst hobbyists, either. *All* of you who devote your recreational hours to making and using tools for studying the heavens are members of a unique bunch. Who ever hears of "amateur chemists" or "amateur nuclear physicists" or "amateur microbiologists"?

You hobbyists do real science. Those of you who take it seriously provide data that advances our knowledge of how the universe works. Understand that and take pride in it. If you do, it will not bother you in the least that there is a difference between what you do and what the professionals do. We have a genuinely symbiotic existence.

— *Derral Mulholland*
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A Flash of Light

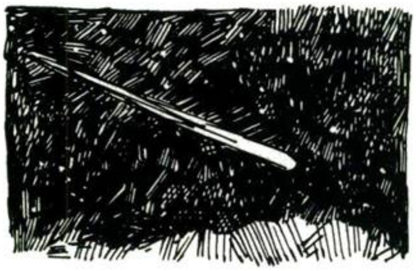
Human beings are constantly bombarded by light. Some of this light is made by the stars, and some of it is made by humans. Most people tend to find the human-made lights more exciting, and in a way this is not surprising, since this light was designed specifically to stimulate us. The bright, flashing lights of stores, advertising signs, discos, laseriums, fireworks, and video games are meant to dazzle our senses through sheer motion, rhythm, color and intensity; and the light of television and movie screens is meant to get us emotionally involved in human stories. The lights of the night sky are not nearly as good at stimulating our sense, nor can they give us the kind of satisfaction that comes from human involvement. Yet if you are attuned to them, the lights in the sky can give you a satisfaction far deeper than any you can get from human lights.

Everyone needs human things, of course, but people who know only human things are missing out on a source of great meaning and beauty. Everyone should occasionally get away from the commotions and emotions of human things, and give the lights in the sky a chance to excite other emotions. Thus it was that I found myself heading away from the lights and the sounds of the city one evening. I walked past the bright store windows filled with colorful merchandise, past the neon signs trying to excite various appetites, past the movie marquees and the crowds hoping to be excited by some new monster or murder or passion or war, past the restaurants whose pleasant lighting and aromas invite you in, past the pounding lights and music of discos, past the video arcades where people stared into fake little skies, past the apartments and houses whose windows glowed a faint television blue, past the street lights and the car lights. I walked until the only lights left were the lights of the sky.

I wasn't out to look at anything in particular. I simply wanted to be surrounded by lights that had been shining for billions of years, not to impress anyone, but because they are what they are. I wanted the rain of starlight to wash the human lights and the petty feelings from my brain. I wanted to feel myself to be a participant in a vast, ancient, dynamic universe.

I looked at the stars for a while. I absorbed the silence of the night. Then suddenly a new light appeared amid the stars, streaked a short way across the sky, and disappeared. This light was very faint, and it was gone before I had time to be surprised. Visually it wasn't much compared to the flashing lights of the city. Yet the people in the city had missed something amazing.

Though it is called a "shooting star" or a "falling star," that flash of light was actually made by a grain or small clump of dust entering the atmosphere and burning up. This grain of dust probably had once been part of a comet. For billions of years this comet had circled the Sun in an orbit far beyond Pluto, so far out that the Sun was little brighter than any other star. Then something had perturbed the comet and sent it toward the Sun. The comet crossed the orbit of one planet after another, and as it neared the Sun its icy surface began to melt and stream out behind it in a long tail. Gas and dust and rocks were sprayed into space, but they continued flying on the path the comet was following. The comet rounded the Sun and looped far out into the solar system, and so did the particles it had lost.



Again and again the comet approached the Sun, and each time it sprayed more particles into space. Some of these particles eventually ran into planets and moons quietly adding another grain of dust or another gas molecule to a world of dust or gas. But on one planet the arrival of the grain of the comet was different, for here its arrival might be witnessed by living beings. In that momentary flash of light, I was witnessing the end of a five-billion-year journey that had carried a grain of dust very far from the Sun and very close to the Sun. This grain of dust may even have been on a long interstellar voyage, for its comet may have once circled another star and encountered a planet that flung it out of that solar system and toward ours.

Perhaps that comet swept past Earth many times and glowed in our night sky and stirred up a great commotion among humans, who spoke of gods and omens and the end of the world. And now, centuries or millennia later, the grain of dust whose glow had stirred such emotions once again glowed in our sky, but this time it was received very quietly. Perhaps I was the only person to witness the dust's arrival. I had no way of knowing exactly where this grain of dust had been. I could know only that this flash of light signaled the completion of a vast, mysterious odyssey.

Or, though it is much less likely, this grain of dust may have been a piece of the Moon. For a few billion years this dust may have sat on a dusty plain and occasionally been tossed about by meteor impacts. Then an especially big meteor struck with enough force to shoot rocks and dust entirely free of the Moon. This grain of dust flew into space, perhaps going into orbit around the Sun, and eventually it found its way to Earth and me. After eons on a world of dust, this particular grain had joined a world of life, and now its dissociated atoms could be breathed into bodies or sucked into plants and become a working part of living cells, and of humans. So perhaps that flash of light was not as much an end as it was a beginning, and I should welcome it to its new home and its new career.

Or, this grain of dust may have been a part of Mars. It may have participated in the evolution of Mars, been shot out of volcanoes and swept down rivers and swirled in dust storms, until one day a meteor struck and hurled it into space. For millions of years it may have been drifting closer to the Sun, and then run into the planet Earth.

Or perhaps long ago an asteroid had been shattered in a collision with another asteroid, and now a little piece of that asteroid was further shattered by a collision with an atmosphere.

But whether it had been part of a comet, moon, planet, or asteroid, this grain of dust, or rather its atoms, had probably been part of a star or several stars long ago. For eons those stars had poured out light, and finally they poured out their own matter, which drifted through space and formed a new solar system. Tonight those stars shone again in a faint echo of their former brilliance. That flash of light truly *was* a shooting star.

Whatever it had been part of, wherever it had been, this grain of dust was now a part of the planet Earth, and I have been here to welcome it. Other people could have been here too, but for some strange reason they had stayed in the city to gaze at lights far less meaningful and beautiful than the *flash of light made* by a grain of dust arriving on Earth.

Don Lago
Columbia, MO

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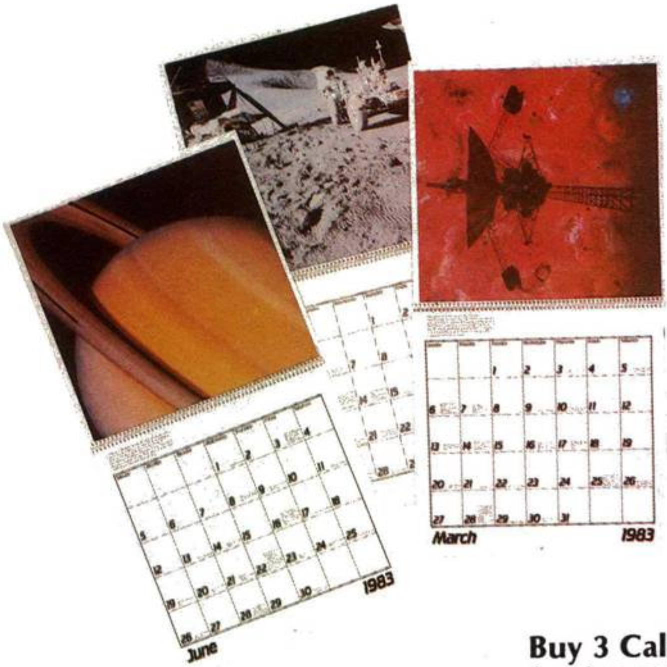
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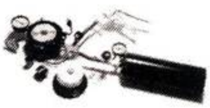

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False Issue

Sir / I've been reading a succession of "Space vs. Welfare" opinions in In Focus over the past few years. I think it's a false issue.

As long as some space exploration advocates can direct their resentment at the so-called "welfare loafers" they see in competition for federal dollars and resources, they are diverting their attention from the truly massive waste on military expenditures, with its weapons of mass extermination produced ad infinitum, its cost overruns, and its giveaways to foreign tyrannies.

The same administration which has been cutting back funds for human services and environmental protection has been gutting the planetary exploration program and the Halley mission. (The Space Shuttle, of course, enjoys strong funding, presumably because of its military applications.) These are just two sides of the same mania.

This is *our* money they're playing with. Those of us who support a peaceful planetary program should not make scapegoats of welfare recipients, who are victims of the economic system. We should, instead, challenge the twisted priorities of the Reagan regime, which victimize all of us.

John Ascenzi
Philadelphia, PA

Siting the 200-inch

Sir / Your story on the 200-inch Hale telescope ("The Glass Giant of Palomar," May 1982) left out one element — you didn't tell how they chose the place to put it. Dr. John Anderson, a Pasadena resident connected with the Mt. Wilson Observatory and a competent astronomer, was in charge of the search. To test the seeing conditions at possible sites, he hired college students majoring in physics and engineering — I believe there were nine of us — and provided each with a 4-inch refractor having a heavy base and an eyepiece with a star-diagonal. These telescopes were designed to look only at Polaris and had thumb screws in azimuth and elevation with sufficient range to follow the small circle that Polaris makes.

Each observer was given an instruction text and printed forms for recording the apparent motion of Polaris in terms of its own visual image diameter. In good seeing conditions, Polaris would jiggle no more than a quarter of its image diameter. We were told to estimate the jiggle to the nearest tenth of a diameter.

I was sent to survey a site in the Mono Lake area, and I'll never forget going up there; I was 19 and I made the trip in my purple Ford Model T in May 1929. My telescope was in a wooden box lashed to the running board on one side, and my camping tent and equipment were on the other. Once I hit the California desert, the road was all dirt with a washboard surface that rattled my back teeth.

I camped near June Lake, 7,000 feet up in the Sierras, until September, taking readings every half hour from dusk to 10 p.m., and then at 12, 2, and 4 a.m. Dr. Anderson visited me to check my location and to compare my readings with his, and once a team from Pomona College came up and stayed a week for another comparison of their readings against mine.

It was lonesome work most of the time, but I fished for trout in the lakes and streams thereabouts, and looking at the sky every night under such clear conditions was wondrous. I could easily see Galileo's moons of Jupiter with my 10-power binoculars.

In the end, the site I surveyed wasn't chosen for the big scope, but I wonder if the 200-inch really did get its proper place when they put it on Palomar Mountain. One of the other locations might have been a better choice in the long run — farther from the city lights and smog which hound the telescope today.

James H. Love
Ventura, CA

Just for Fun

Sir / Three years ago I was observing Sagittarius through my old 10x50 binoculars. M-8 was visible in my eyepieces, but somehow I did not see it; I was letting my mind wander. I thought I was alone in the astronomy world — the only person without a telescope, the only person with just an old pair of binoculars.

But then I began to think. I wasn't alone or deprived. Some people had only their eyes to observe with. That made me feel so good. I may have smiled the biggest smile I ever will. I may have even shed a tear of happiness. Then I took my binoculars off their mount and put them away, safely in their case. I began to observe with my unaided eye. I did that for three days and was amazed at the things I saw.

Now, three years later, I have much more equipment and experience. But more often than not, I take out those trusty old binoculars and look at the same objects I did then. Then I think back to when I thought I was alone and I realize that astronomy isn't buying a larger telescope than you have now, and astronomy isn't wishing you could see more than you see now.

Astronomy is observing what you can — just for fun.

David L. Donnell
Rover, AR

Oort Cloud Problem

Sir / Francis Reddy's "Backtracking the Comets" (ASTRONOMY, August 1982) lists some problems with all theories about the Oort cloud. I'd like to suggest another.

The Oort cloud is an incredibly difficult and imprecise target in terms of velocity, and any mechanism that sends comets to the Oort cloud is bound to send a lot more into interstellar space. Further, planetary interactions are also sending comets into interstellar space. Our solar system is littering the Galaxy with comets. Fine. There's plenty of room for them to get lost in — as long as the other stars aren't doing it, too. The size of the Oort cloud compares with interstellar distance, so if free comets are more common in the Galaxy as a whole, they should also be more common in the range where we can observe them. We are right back to the problem of no hyperbolic orbits — unless we assume the Sun is a very unique object.

Perhaps there is some sort of damping zone that kills most of a comet's velocity relative to the Sun, then lets it drop toward the solar system on an elliptical orbit. It's quite a job for any comet cloud out there. Maybe electrostatic drag could help.

Richard V. Grant
Middletown, PA

Astro-Poetry

Sir / In the May 1982 issue, Robert Purvis inquired about astronomical references in poetry other than his quotation from John Keats. He might be interested in Alfred Noyes's book, *Watchers of the Sky*, which was published in 1922 and was inspired by the 100-inch telescope on Mount Wilson. Noyes was present at its first trial.

The book was to be the first of a trilogy dedicated to three phases of science. I also have a copy of the second in the series, *The Book of Earth*, which is on geology, but know nothing of the third volume.

I am sure a collection of poetry on astronomical topics would be interesting and fun to put together. Noyes writes in his preface that "Tycho, Kepler, and many others wrote a considerable number of poems" and makes specific reference to poetry/science contacts between Sir Henry Wotton and Kepler, and between Milton and Galileo while the latter was in prison. I suspect these are only a beginning.

Francis R. Nitchie
Pukalani, HI

Comet Data Needed

Sir / Two friends of mine and I are working on recovering the periodic comet Dubyago, also known as P/Comet 1921 I (1921c). We'd appreciate hearing from anyone who has positions for past apparitions of this comet. We hope to publish the results, and any help we get will be appropriately credited.

Charles Townsend
3521 San Juan Ave.
Oxnard, CA 93033

Lunar Eclipse

Sir / My family and I stayed up all night to see the great lunar eclipse of July 1982 — a lovely and moving phenomenon.

It was a beautiful naked-eye sight, but up on the roof of my house, I couldn't help but set up my 60mm 500x refractor telescope. I observed the Moon under the following magnifications: 50x, 80x, 167x; with the Barlow lens: 150x, 240x, 500x. I admit the Moon doesn't look quite as beautiful at 500x! You don't really see the beauty of the eclipse and the colors.

I don't have the camera equipment to "Shoot the Moon," but the image still and will always remain in my memory.

I am soon to go into the tenth grade and my hobby, astronomy, I hope will grow to a profession.

Zac Colton
Lynn, MA

Ooops!

The eclipse photo on page 43 of the October issue should be credited to Peter Simson, not Simpson, and Prudence Goodman.

behind the scenes

a year ends: a year begins

This is a very special issue of ASTRONOMY, an issue in which we pause for a moment to reflect on the past and look forward into the future.

Our feature on Yerkes Observatory refracts us back to an earlier era in astronomy, an era in which the astronomer's eye was all; and to a man, George Ellery Hale, who may have done more than any astronomer to usher in the new era of astrophysics. This article, well over a year in the works, was *not* written by a astronomer or a writer, but by an artist, Bruce Bond, a man whose enthusiasm for his subject shines from every page.

In Photography in Astronomy, we take stock of the year's events through pictures sent by our readers; and in Equipment Atlas, we survey the rapidly changing landscape of amateur and commercial telescope making. Our Forum authors continue the on-going debate over the role of "amateurs" in astronomy — and we see that under the sound and fury, there is some basic agreement.

Looking ahead, the next issue marks the beginning of my eighth year with ASTRONOMY. The last seven years have required plenty of tough decisions and hard work, but have given me considerable satisfaction. Yet the credit for what ASTRONOMY is today goes to you, the readers. Above all, my role has been to *listen* to what you have to say, rather than *tell* you what ASTRONOMY should be. I look ahead to the coming years.

I'd like to end by introducing you to two new members of our editorial staff: Frank Reddy and Dave Eicher. Both have contributed to ASTRONOMY in the past: Frank in the August feature, and Dave most recently in the September 1981 Gazer's Gazette. You will become familiar, I am sure, with their writing in future issues — though their contributions to this issue are already significant.

Sincerely,

Richard Berry

Richard Berry
Editor

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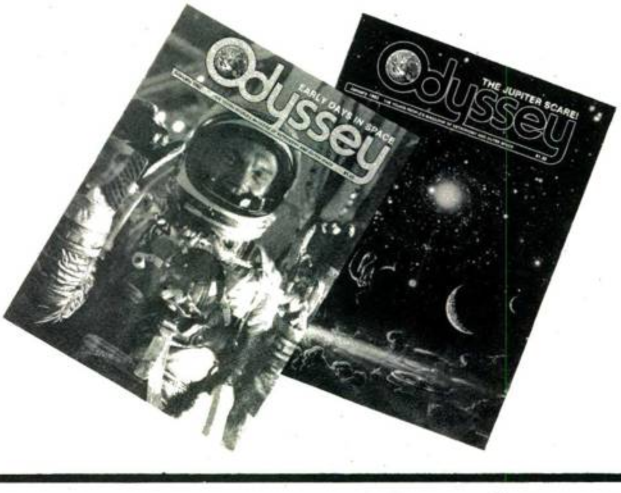
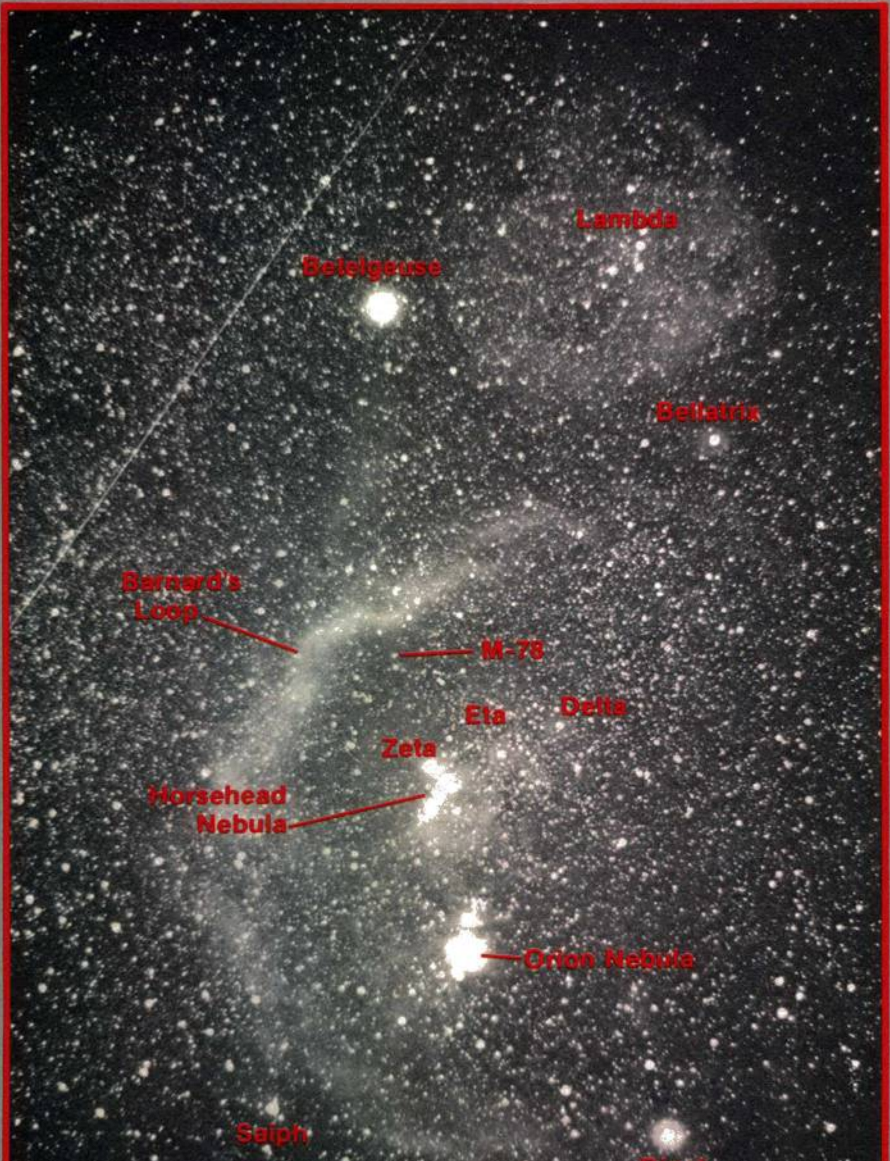


gazer's gazette

exploring the nebulosities of orion

by Gary Keltner



The main stars of Orion show distinctly in this red-light photo. The C-shaped nebulosity on the left is Barnard's Loop — a swirl of dimly-glowing hydrogen gas, invisible to the eye but prominent in long-exposure photos. An even dimmer nebulosity surrounds Lambda Orionis at top right. Photo by Jack Marling.

The crisp, cold skies of winter offer many challenges for the backyard observer. And of all the constellations visible at this time of year, none generates more fascination than Orion, the mighty hunter. One of the most recognizable and visually striking naked-eye star patterns, Orion is a treasure chest of interesting deep-sky objects for owners of medium-size (6 to 8-inch) telescopes. And nowhere else in our observable heavens can such excellent examples of both bright and dark nebulosity be found in one area.

Having been a deep-sky addict for several years, I have enjoyed many a frosty evening at the eyepiece, marveling at these wonders in Orion. Since tonight looks clear, let's put the coffee pot on the stove, don our parkas, and head outside to the telescope for a tour of a few of Orion's nebulosities.

Our obvious starting point is the magnificent object most often called simply "The Great Nebula." No name could be more appropriate, for this spectacular star factory has captured the imagination of nearly every observer since the invention of the telescope.

With its wealth of detail and color, it is indisputably the best example of a bright diffuse nebulosity available to northern hemisphere observers. Easily located with the unaided eye as the fuzzy middle star in Orion's sword, this cloud of gas — known also as M-42, for its place in Charles Messier's roster of "false comets" — is an impressive sight even in a modest telescope. And the view with a 6 to 8-inch scope using a wide-angle eyepiece is stunning.

Let's now explore some of M-42's more interesting aspects. Using your lowest power eyepiece, center the brightest portion of the nebula in the field; 30x to 40x gives a fine overall view in an 8-inch f/6 reflector. You are looking at perhaps the only place in the heavens where a visual observer can glimpse complex nebular structure — a feature normally seen only in long-exposure astrophotos.

At low magnification, this structure appears as a general mottling of the nebula's surface, but increase your eyepiece power to about 70x, and an immense amount of intricate detail becomes visible. On an exceptional night, my 8-inch will show a multitude of knots and wispy filaments traversing the nebula's bright central portion. This is especially apparent near the famous quartet of stars that make up Theta (θ) Orionis — a group known by its shape as the Trapezium. These are the hot blue stars whose ionizing ultraviolet radiation is responsible for the entire nebula's luminescence. In this region, new stars are being formed from globules of dusty gas.

The delicately-structured region near the Trapezium is often obliterated in observatory photographs due to extreme overexposure. Astronomers do this purposely, of course, so the photos can reveal the faint outer extremities of the nebula. The encouraging fact remains, however: Visual observers may still have the upper hand when it comes to some types of observing.

In this central region, you'll also find the so-called Dark Bay or Shark Mouth, an elongated black wedge of dust that juts into the nebula from the east. Under good observing conditions, the stark contrast between the blackness of the Shark Mouth and the brightness of the nebula is breathtaking.

Across the Bay to the northeast of the main mass of the nebula, you will see a small detached portion known as M-43. The same wispy detailing and greenish color as in the main body appears here, though to a lesser extent. In addition, you may detect a few dark rifts and splotches; look also for the nebula's light source, an eighth-magnitude central star.

When you've seen your fill of the Trapezium region, shift back to a low-power eyepiece and swing your scope slowly southwestward, toward the outer fringes of the Great Nebula. How far can you trace the faint filamentary streamers from the nebula's main core? A truly superb night should enable you to follow an obvious arc starting at the nebula's northwest fringe and circling around toward its southern extremities. You won't see the complete circle of nebulosity shown in photographs, but you should be able to trace the arc for several degrees on each side of the main nebula. To me, tracing out the filaments until they merge with the black of space has always been one of the most interesting and mysterious aspects of observing M-42.

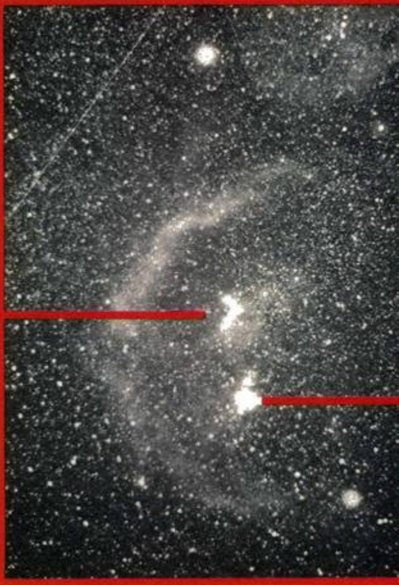
Under most sky conditions, and with apertures of 8 inches or less, M-42 exhibits a definite greenish tint. But under ideal skies, you may see some reddish or rusty coloring in its outer fringes. Although many observers will swear up and down that the reddish hues are not visible, my friends and I have seen them several times — though never in anything less than an 8-inch telescope under dark, pristine skies. When these hues *are* visible, they give the entire nebula an eerie three-dimensional effect you'll have to see to believe!

Before venturing too far away, there are at least two more objects worthy of attention, both located almost due north of the Great Nebula. NGC-1977 is a large but very faint diffuse nebula involving the fifth-magnitude star 42 Orionis, which lies about half a degree north of M-42. With its low surface brightness, NGC-1977 does not reveal much detail in small instruments — though you can probably pick up a dark lane cutting through the nebula from east to west. Even this isn't always easy, however, as both parts of the nebula are not always visible.

Just north of NGC-1977, you will come across one of the prettiest star fields in the entire constellation — the scattered, open star cluster NGC-1981. Again use your lowest-power, widest-field eyepiece for best effect. The stars range in magnitude from 8 to 10, and should nicely fill your field of view. You'll also find many other attractive star groupings in this area, so spend some time here, sweeping your scope around.

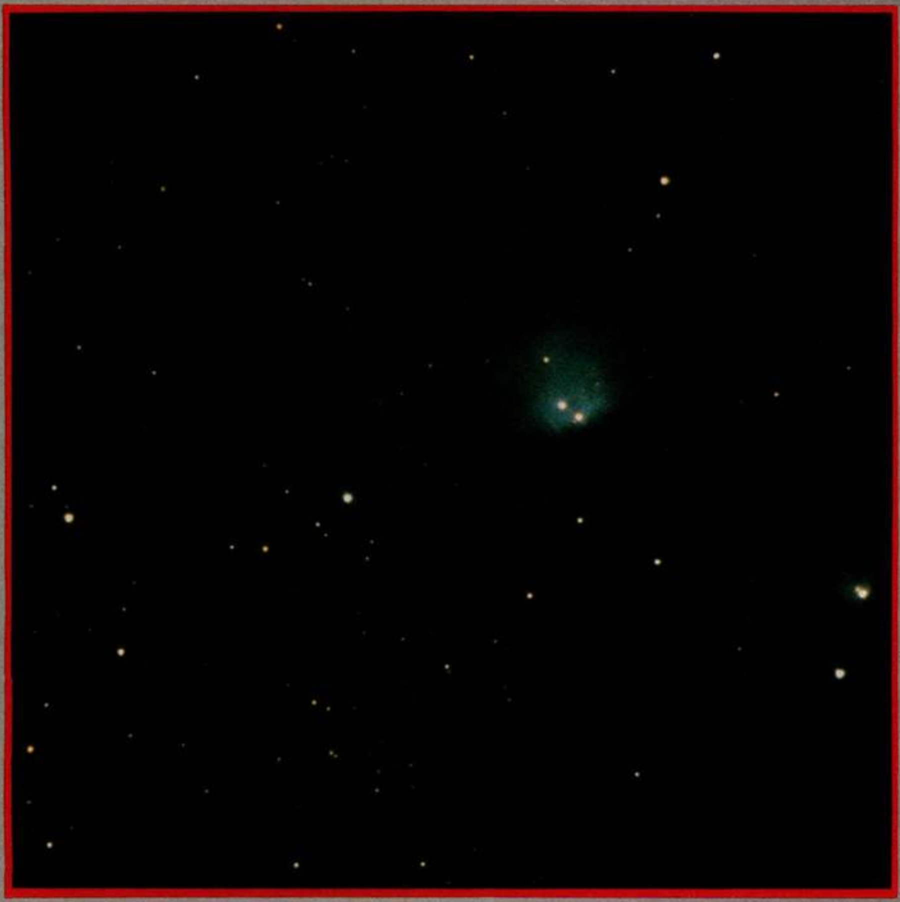
Leaving the wonderful nebular complex, we can now move on to some of the less spectacular, though no less interesting, deep-sky treasures in Orion. Besides the two objects detailed earlier, comet hunter Charles Messier logged one other of his "false comets" in Orion — the small diffuse nebula M-78, which lies in the northeastern part of the constellation. This object is often overlooked by many observers — partly because of its competition to the south and partly because it is a rather difficult object to locate, having no bright finder stars nearby.

M-78 is definitely worth finding — and here's a fairly easy method that works for me. Using the eastern belt star Zeta (ζ) and the third-magnitude star about a degree to the southwest, Sigma (σ), scan along an imaginary line to the northeast about 2½ times the stars' separation. This should put M-78



Right: The sword of Orion consists of three nebulae — M-42, M-43, and NGC-1977 — and a loose collection of stars. Photo by Bill Iburg. Below: South of the bright star Zeta Orionis is IC-434, a faint ruddy smear of gas, with the dusty Horsehead Nebula superimposed upon it. Photo by John Gleason.

Jack Marling



M-78, a small planetary nebula some 3° to the northeast of Zeta Orionis, often passes unnoticed by observers. Closely resembling a comet in the eyepiece, the nebula measures a diminutive 6 minutes of arc by 8. The brightness of the nebula is about 8.3 magnitude; that of its central star is about 10. Photo by Jack Newton.

somewhere in your low-power field of view. Look for a small, fairly bright, and somewhat fan-shaped nebulosity involving two tenth-magnitude stars. To me, this is one of the few objects in Messier's catalog that actually does resemble a small comet.

Now that we've knocked off the "easy stuff" in Orion, it's time to go for one of the most difficult challenges available to the visual observer — the famous Horsehead Nebula. The Horsehead is a prime example of how valuable time-exposure astrophotography is compared with the human eye. Bear this in mind from the outset: if you hope to see anything remotely resembling what big-telescope photographs show, you are due for a disappointment. Even under the clearest and darkest skies possible, conditions have to be exactly right for you to detect it at all.

For example, my first glimpse of the Horsehead came several years ago in a friend's 6-inch reflector. Since that time, I have made several attempts to see it with 8-inch f/6 and f/7 reflectors, but without success. The sky conditions — darkness, transparency, seeing — all seemed as good as in the first sighting, but the Horsehead simply refused to reveal itself. Finally, my patience (and frozen feet) were rewarded with a remarkable view of this elusive object in my 8-inch f/6. Here's my method for locating the Horsehead:

Before you make any attempts, familiarize yourself thoroughly with the Zeta Orionis region. A good atlas, such as the *Sky Atlas 2000*, is essential, but perhaps even more important is a good finder chart, such as the excellent one found in *Burnham's Celestial Handbook*. This latter book also contains many fine wide-field photos of the Horsehead region — useful reference material to study.

Before you're ready for your attempt on the Horsehead, one additional factor is necessary: a clear, transparent sky totally unhampered by moonlight or city lights; this may mean traveling many miles from home. You'll also want to pick a time when Orion is at maximum elevation, on or near the meridian. (During December, this is around 11 p.m. to 1 a.m. local time.) Finally, as you saw before with the other nebulae, a low-power ocular with a wide field is extremely helpful — I used 40x on my 8-inch f/6 and the actual field of view was just under a degree in diameter.

To prepare yourself, you'll have to dark-adapt your eyes thoroughly — which means no lights or flashlights for at least half an hour before you start looking. This gives your pupils time to expand to full aperture, and makes your retinas "fully alert." Start your Horsehead search by centering the scope on the second-magnitude star Zeta Orionis, the same easternmost belt star we used to find M-78. Just to the northeast of Zeta, and easily in the same field, you should immediately become aware of a large, nebulous patch bisected by a dark lane. This is NGC-2024, a very fine diffuse nebula. Using averted vision, can you detect a dark vein-like structure in the nebula's eastern portion? If so, the observing conditions are excellent.

Now, while looking in the eyepiece, carefully swing your scope due south until Zeta lies just out of the field of view to the north. You should see in the field what appears to be an eighth-magnitude fuzzy star. This is the diffuse nebula NGC-2023. Keeping this object in the field of view, move your scope ever so slightly southwest. If conditions are ideal, you should pick up a long faint wisp of emission nebula (called IC-434) running approximately north/south. Again using averted vision — and this can't be stressed enough — ask yourself if you can discern a dark nick or chip in the eastern side of IC-434. If you can, you've located the famous Horsehead!

Don't expect to see much detail or shape — my best observation revealed simply an irregular, semi-circular shape jutting into the faint background glow. Considerably more aperture would be needed to pick out any of the horse-like features familiar from photographs. However, just finding it should give you a thrilling sense of accomplishment. I think it is a supreme test of the sky, your telescope, and your visual abilities. And if you can't see it, don't give up. Though the search may call for patience, perseverance, and a good warm set of long underwear, I'm sure you'll succeed eventually.

The Horsehead makes a fitting conclusion to our tour of some of Orion's more interesting nebulosities, but it by no means exhausts all that's available in this remarkable constellation. There are many other diffuse nebulae and star clusters within range of medium-size telescopes. If I've succeeded in whetting your appetite for more, go and check out the excellent lists of objects in Burnham's and other deep-sky guides. Happy hunting!

Gary Keltner has been observing for the past 14 years. He is a member of a small group of like-minded individuals who observe deep-sky objects exclusively. At present, they are working on observing spiral structure in the brighter galaxies.

ASTRONOMY
REVIEWS

Byers 812 Mounting
Base price: $1650
Edward R. Byers Co.
29685 Cuthbert Rd.
Malibu, CA 90265

For high-quality observations with a telescope, mountings are every bit as important as optics. Russ Porter pointed this out in *Amateur Telescope Making, Book I* back in 1935, and gave us detailed sketches of some very stable mountings using conic axles. He also cautioned that amateur telescope makers would probably not be able to make such axles, given the extensive machining required. With such a broad hint, it's a little surprising that commercial telescope manufacturers took so long to respond.

Having wrestled with my own designed-and-fabricated mounting — as well as commercial ones — in remote desert and mountain areas, I was pleased to see the Byers 812 mounting come on the market — especially since it follows the Porter concept so closely. Having now used that mount for several months, I can state that it is just as stable as it looks — provided you use it on its proper tripod. At first I used a sturdy box as a base for the equatorial head, but this was no good: it neither did the mounting justice nor allowed for easy polar alignment.

Besides stability, the Byers 812 has other features astrophotographers have always wished for, so here are my comments on each:

Rapid polar alignment. This is necessary to save valuable observing time. The Byers 812 has a non-optical peep sight to allow a quick set-up on Polaris. At first, you'll think this peep sight should be larger to make it easier to find Polaris, but its size is designed so that when the star is at the edge of the field of view and you have positioned the mount so that the center of the field brings a line from Polaris to the end of the handle of the Big Dipper, the coarse polar alignment is complete.

Large worm gear. This 11-inch diameter gear is a real plus, but to achieve it and still maintain portability, Byers had to compromise — therefore you don't get a full circle gear, but a sector that has to be reset every 2 hours. Moreover, you have to do this with care or you'll nick up the worm and gear. And besides the sector, you have to reset the RA circle as well.

Though it sounds like a nuisance, in practice two hours is probably enough — I've taken only 3 photos longer than 90 minutes — but the time goes by very rapidly when you add in set-up time for each exposure.

5 arc-second gear accuracy. This kind of precision is better than the other errors inherent in portable set-ups, but it certainly is nice. With careful polar alignment and a reliable power supply, I find that 10 minutes usually go by before I have to make a correction. This ease of operation eliminates the fatigue of constant corrections to the guiding and makes long spells of photography attractive.

Hand-adjustable clutches. Well, you'll still need a 0.188-inch hex-wrench to secure the mount to the tripod after polar alignment and you'll also need a 0.125-inch hex-wrench for that nasty little hand-operated declination clutch.

Size. The 812 is unquestionably heavy: the mounting weighs 47 pounds, and the tripod adds an additional 20 pounds. But their dimensions are such that even a small passenger car can transport you, an assistant, and your equipment to any site, provided you can "car-top" at least part of it.

Other features. A minor annoyance is the full-threaded counterbalance shaft — it takes forever to remove weights for transport, though it is definitely safer than a set screw. On the plus side, the channeled platform supplied is very stable and versatile enough to accept most tube-ring assemblies or flat-mounted instruments.

All observers with big equipment — whether astrophotographers or just plain observers — owe Edward Byers a vote of thanks. In the 812, we now have good portability, quick polar alignment, and drive accuracy second to none. *Ronald E. Royer.*

Observatories of the World
Siegfried Marx and Werner Pfau
200 pages, hardcover, $16.95
Van Nostrand Reinhold (1982)

Though it doesn't list every single professional observatory in the world, this book still manages to provide photos (about a third of which are in color) and a descriptive survey of all the world's major installations and a good number of minor ones as well.

The endpapers have a map of the world with little domes on it to show where the optical observatories are and little radio dishes to show the radio facilities. The extent of astronomy's "northern hemisphere chauvinism" is very marked — Europe and North America are crowded with observatories, while only a few are scattered across the middle southern latitudes.

Mission to Mars
James Oberg
224 pages, hardcover, $14.95
Stackpole Books (1982)

Manned missions to Mars have long been a fabulous dream to many people. In this book, Oberg presents a general plan which shows that going to Mars would take less time to develop and cost less money than most people believe, and would have great scientific and cultural benefits.

Catalogue of Comet Orbits, 4th ed.
Brian G. Marsden
97 pages, papercover, $10
Minor Planet Center (1982)
[publisher's address: 60 Garden St., Cambridge, MA 02138]

This new edition of an old standby lists the orbital elements and periods of visibility for some 1100-plus cometary apparitions that have been observed up to May 1982. It also has supplementary tables of references, appearances of periodic comets, breakdowns by orbital type, and so on.

Evolution from Space
Fred Hoyle
80 pages, hardcover, $8.95
Enslow (1982)

This slim volume contains three essays by Hoyle (one co-authored with Chandra Wickramasinghe) on the origin of life. Aimed at popular level audiences, the essays expound Hoyle's thesis that life on Earth came from space.

In general, this theory has met with skepticism from other scientists; it is definitely "heretical" in a Kuhnian sense. But as usual, Hoyle is a master in arguing his case. Even if you're not quite as convinced the following day, the experience is very enjoyable — if only to observe the zest with which Hoyle takes on his opponents.

Classics in Radio Astronomy
W. T. Sullivan, ed.
348 pages, hardcover, $59.50
Reidel (1982)

Taking some 37 papers that date from 1896 to 1954, Sullivan presents a "history" of radio astronomy. Those chosen have become classics in the field, and several are given in full translation for the first time. Sullivan has also added a commentary to place each in historical perspective and to indicate where the field has developed since the paper was written.

Plurality of Worlds
Steven J. Dick
246 pages, hardcover, no price given
Cambridge University Press (1982)

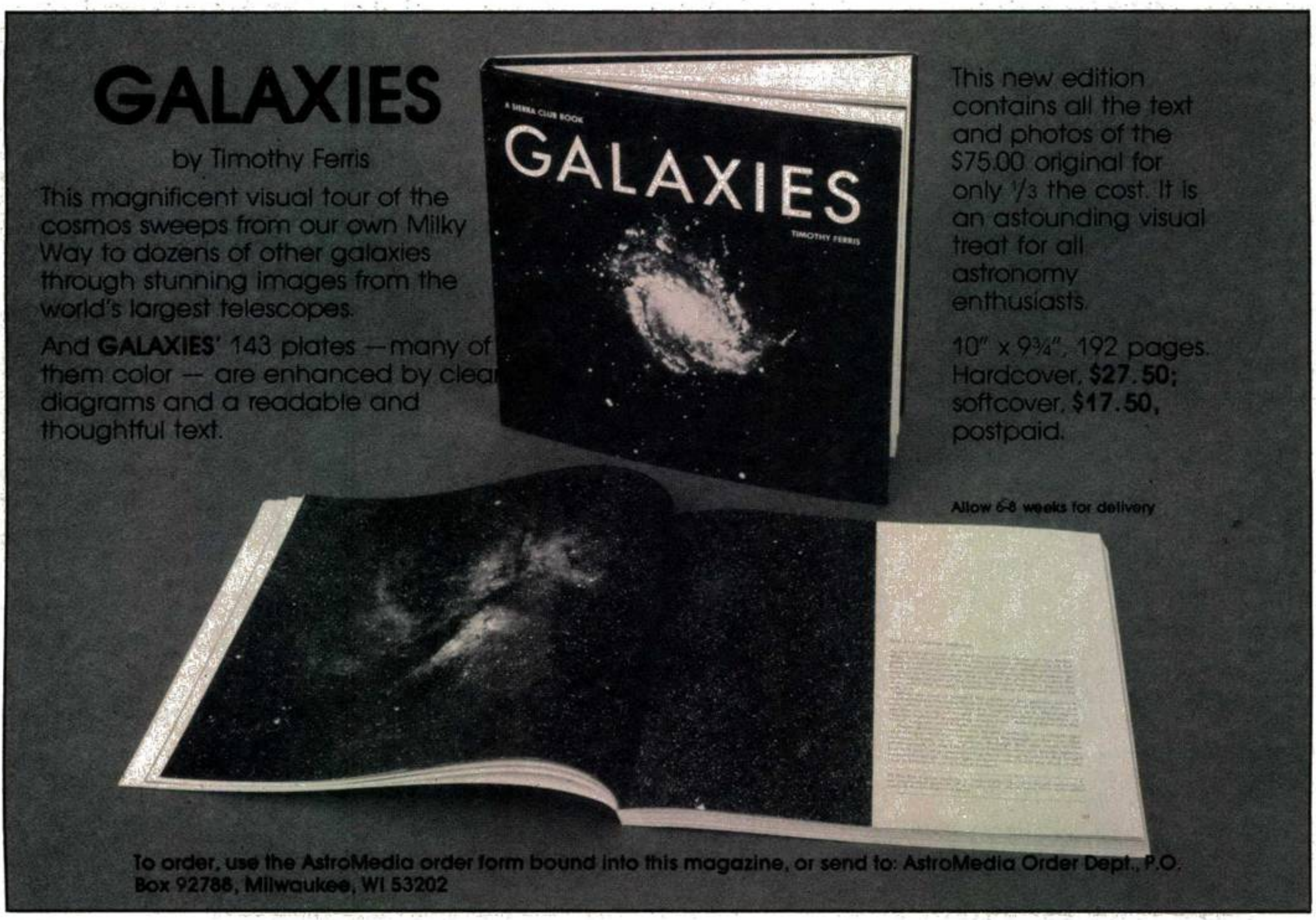
Subtitled "the extraterrestrial life debate from Democritus to Kant," this book is the first work to survey the history of the subject, and shows that the notion of creatures inhabiting planets other than the Earth goes back a long time.

Voyages to Saturn
David Morrison
227 pages, paperback, $9.50
NASA (1982)

This fine paperback, loaded with color photos, tells two stories: the first concerns what scientists knew about Saturn before Voyager and what they learned from the mission; the second is a log of events describing the two encounters on a day-by-day basis. Morrison is an experienced planetary astronomer and a member of the Voyager imaging team.

Binary and Multiple Stars as Tracers of Stellar Evolution
Zdenek Kopal and Juergen Rahe, eds.
503 pages, hardcover, $67.50
D. Reidel (1982)

The problems that binary stars offer to astrophysicists are substantial, and accounting for the evolution of these stars is difficult. Mass can be transferred from one star to another and, in the process, change the temperatures and chemical compositions of the component stars. This book prints the papers given at an IAU colloquium in August/September 1981.



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Automated Data Retrieval in Astronomy

C. Jaschek and W. Heintz, eds.
324 pages, hardcover, $48
D. Reidel (1982)

Although astronomy, like every other science, has entered the "information age," many astronomers tend to view automated systems with some skepticism. From a conference that began with the title subject and wandered further afield to include such subjects as copyright and editorial policies of professional journals, some 60 papers have been reprinted. Although the collection is aimed at the professional scientist, anyone with an interest in the subject might get some enjoyment out of browsing through a library copy of the book.

Solar Variability, Weather, and Climate

Geophysics Study Committee, NRC
106 pages, paperback, $11.95
National Research Council (1982)

As the authors note in their introduction to this collection of 8 papers, "much of the doubt about real Sun-weather connections stems from a lack of proposed physical mechanisms. . . ." They go on to make three recommendations for future research: closer examination of the Sun's effects on Earth's atmosphere, development of physical models for solar changes in the terrestrial atmosphere, and expansion of the data base on Sun-weather and Sun-climate effects.

"Subtle is the Lord . . ."

Abraham Pais
552 pages, hardcover, $25
Oxford University Press (1982)

This biography of Einstein differs from most in that, besides the strictly biographical sections, the bulk of the book deals with Einstein's scientific work in a biographical way. As a result, Pais traces the origins of his ideas and their interactions on other physicists.

Key Definitions in Astronomy

Jacqueline Mitton
168 pages, paperback, $4.95
Littlefield, Adams (1982)

The entries in this brief dictionary cover almost 250 words of specialized usage in astronomy and space science. The definitions range from one sentence to two or three paragraphs and are amply cross-referenced. They are written on an introductory level.

Selecting Your First Telescope

Sherwood Harrington
14 pages, papercover, $2
Astron. Soc. of the Pacific (1982)
[publisher's address: 1290 24th Ave., San Francisco, CA 94122]

This "book" is really a reprint of an article that appeared in the A.S.P.'s bimonthly magazine *Mercury*. It discusses the various types of telescopes and mountings, and what each is best suited for. It also includes reading lists of books and atlases, as well as addresses of manufacturers.

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eye on the sky

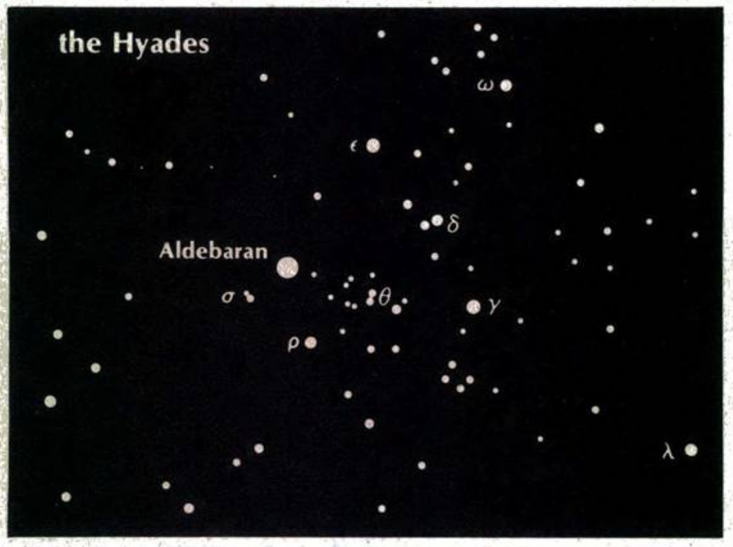
orion ushers in winter

by Fred Schaaf

the wanderers

Though all the planets will remain close to the Sun this month, December should offer some truly exciting sights for sky watchers. Highlights of the month include the return of Venus to the evening sky in the company of Mercury, moonless skies for the excellent Geminid meteor shower, and — perhaps best of all — an encore to last July's remarkable total lunar eclipse.

Three total eclipses of the Moon in one calendar year will not occur again for over 500 years. This last eclipse of 1982, the second visible from North America, occurs in the predawn hours of December 30. It will last only 66 minutes, compared to the 106-minute duration of the July 6 event — the longest lunar totality visible from the western hemisphere since 1736. But the **December 30 lunar eclipse** will probably be as dark and strange as the one in July because of the continuing presence of ash in the atmosphere from the El Chichon volcanic eruption. Above all, this eclipse deserves the attention of North American observers because it will be the last total lunar eclipse visible from this part of the world for many years. For more details, consult The Backyard Astronomer, page 78 of this issue.



The timing of the Moon's phases this month could not be better for meteor watchers: New Moon occurs less than a day after the peak of the **Geminid meteors.** The greatest number of meteors will be visible on the night of December 13-14, with 50 or 60 Geminids per hour likely for an alert observer at a dark-sky site during the hours after midnight. The Geminid radiant — the point on the sky from which the meteors appear to come — is near Castor and is highest around 2 a.m. local time.

If you are up late enough with the Geminids, you will get a chance to see two morning planets rise in the southeast. First to appear is **Saturn**, which lies in eastern Virgo and at mid-month rises around 3 a.m. local time. By month's end, +0.9 magnitude Saturn will lie within a few degrees of the fourth-magnitude star Kappa (κ) Virginis.

About two hours after Saturn rises, **Jupiter** follows. Shining over two magnitudes brighter, this −1.3 magnitude planet ends the year on the verge of entering the bright head of Scorpius and engaging Uranus in conjunction. (Next year will see three Jupiter-Uranus conjunctions.) On the morning of December 28, North American viewers can see Jupiter only 7 minutes of arc south of 5.9 magnitude 47 Librae. Observers using binoculars or other optical aid can follow the star as it briefly resembles a fifth (but spurious!) Galilean satellite.

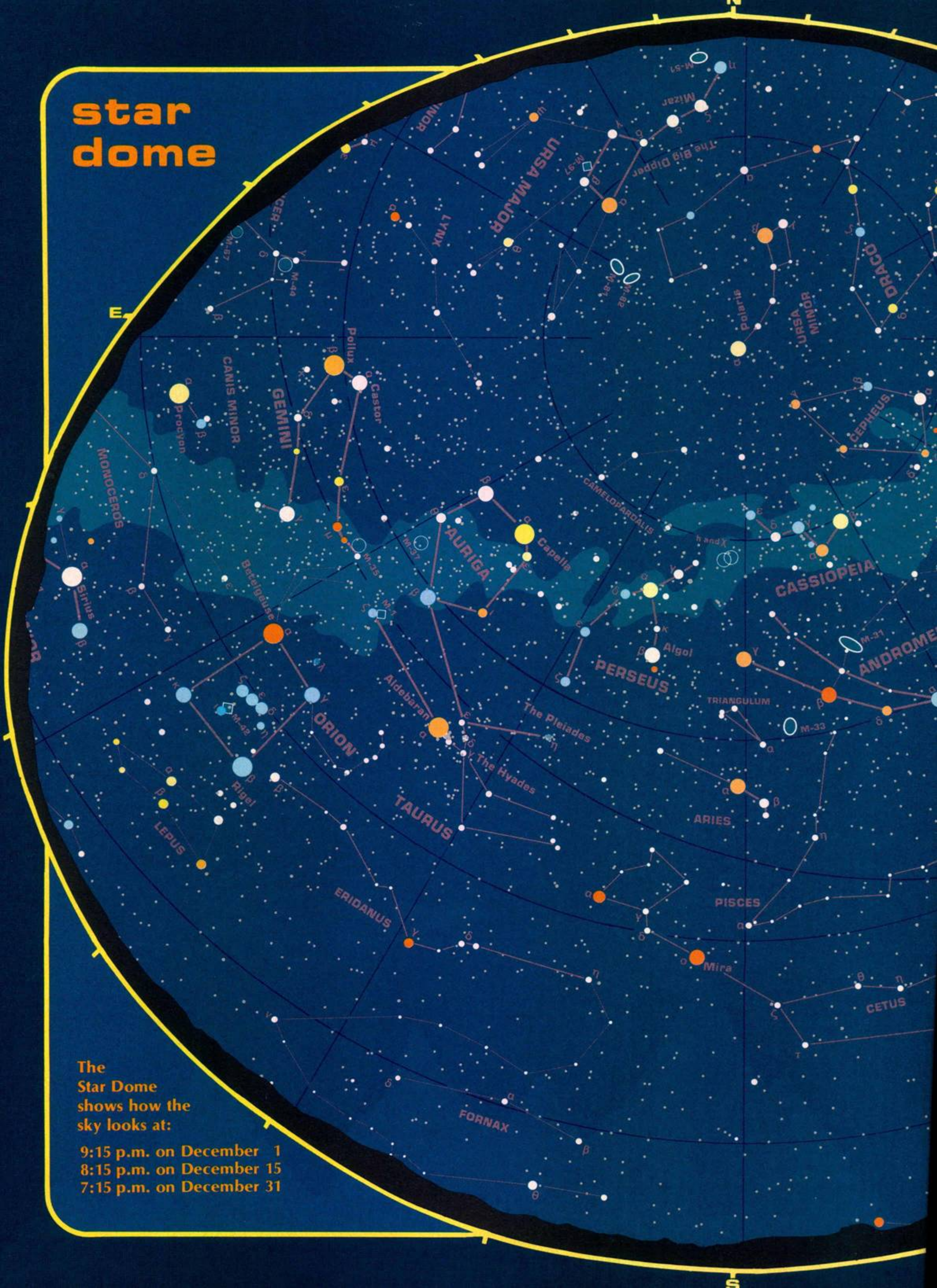
An even more interesting planetary set-piece occurs in the western sky during evening twilight when **Venus** finally emerges from the glare of sunlight. In early December, viewers at 40° north latitude will see the planet set only about 20 minutes after the Sun; by New Year's Eve, the interval will have increased to about an hour. Venus is at −3.4 magnitude — nearly its faintest — because it lies so far from Earth. We are watching it pull slowly away from superior conjunction, which occured early last month when Venus was on the opposite side of the Sun from us.

Venus will have some company in the evening sky: during December, **Mercury** also comes from behind the Sun and will appear briefly over the southwestern horizon. The climax of this relatively good apparition of Mercury takes place on December 30, when the diminutive planet attains its greatest elongation from the Sun, 20°. You probably won't find it difficult to spot Mercury to the upper left of Venus for a week or more before then. The two planets will not appear very close to each other this month, but should make a pretty sight in the fading glow of evening twilight as the year draws to a close.

Much farther from Mercury, above

Hanging low over bare trees, the Moon had just begun to leave the umbra when David Nauer photographed it during the total lunar eclipse on the evening of November 18, 1975. Loading his camera with ASA 160 film and placing it on a tripod, Nauer used a 200mm lens and a 3-second exposure at f/3.5 for the photo.

star dome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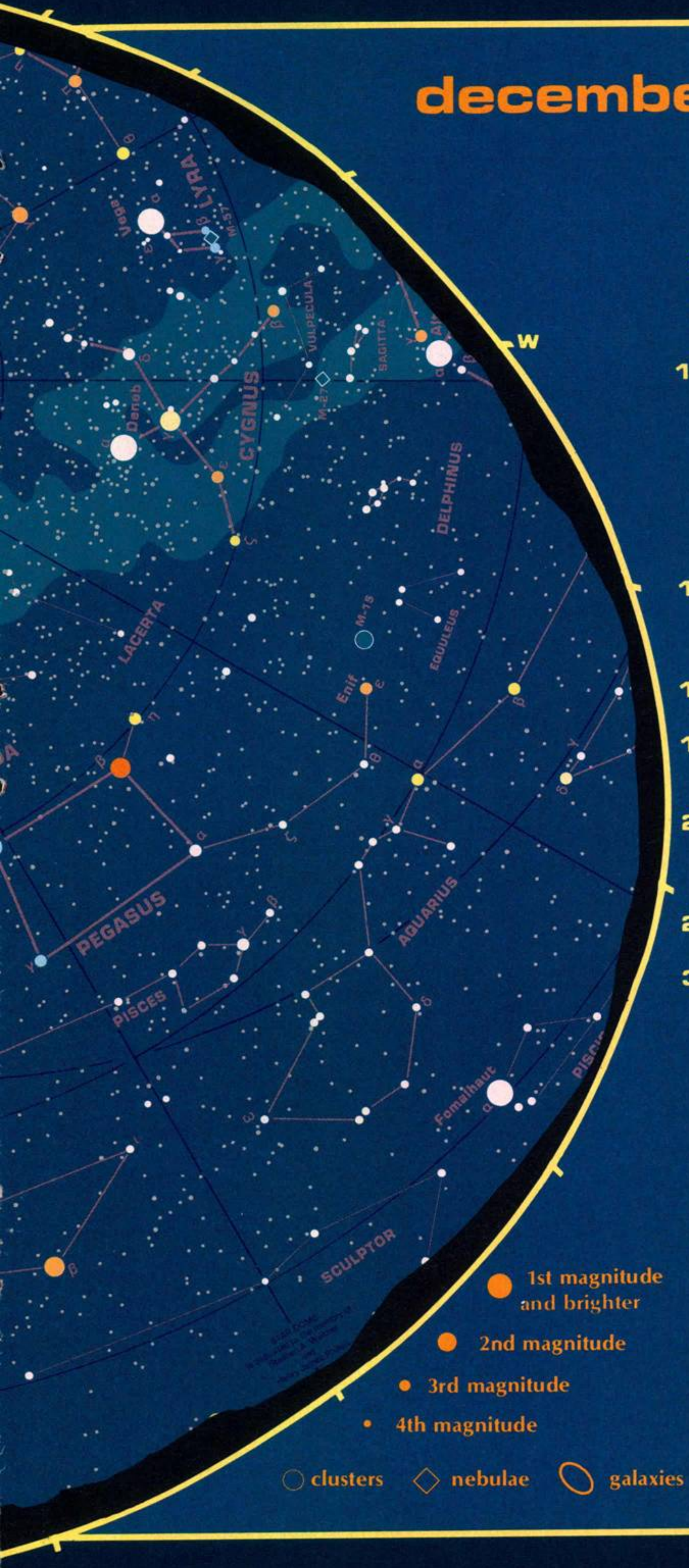
GEMINI
Pollux
Castor
CANIS MINOR
Procyon
MONOCEROS
Sirius
AURIGA
Capella
M-37
M-35
M-1
Betelgeuse
ORION
M-42
Rigel
LEPUS
Aldebaran
The Pleiades
The Hyades
TAURUS
PERSEUS
Algol
TRIANGULUM
M-33
M-31
ANDROME
ARIES
PISCES
Mira
CETUS
ERIDANUS
FORNAX

The Star Dome shows how the sky looks at:

9:15 p.m. on December 1
8:15 p.m. on December 15
7:15 p.m. on December 31


Vega
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M-57
VULPECULA
SAGITTA
W
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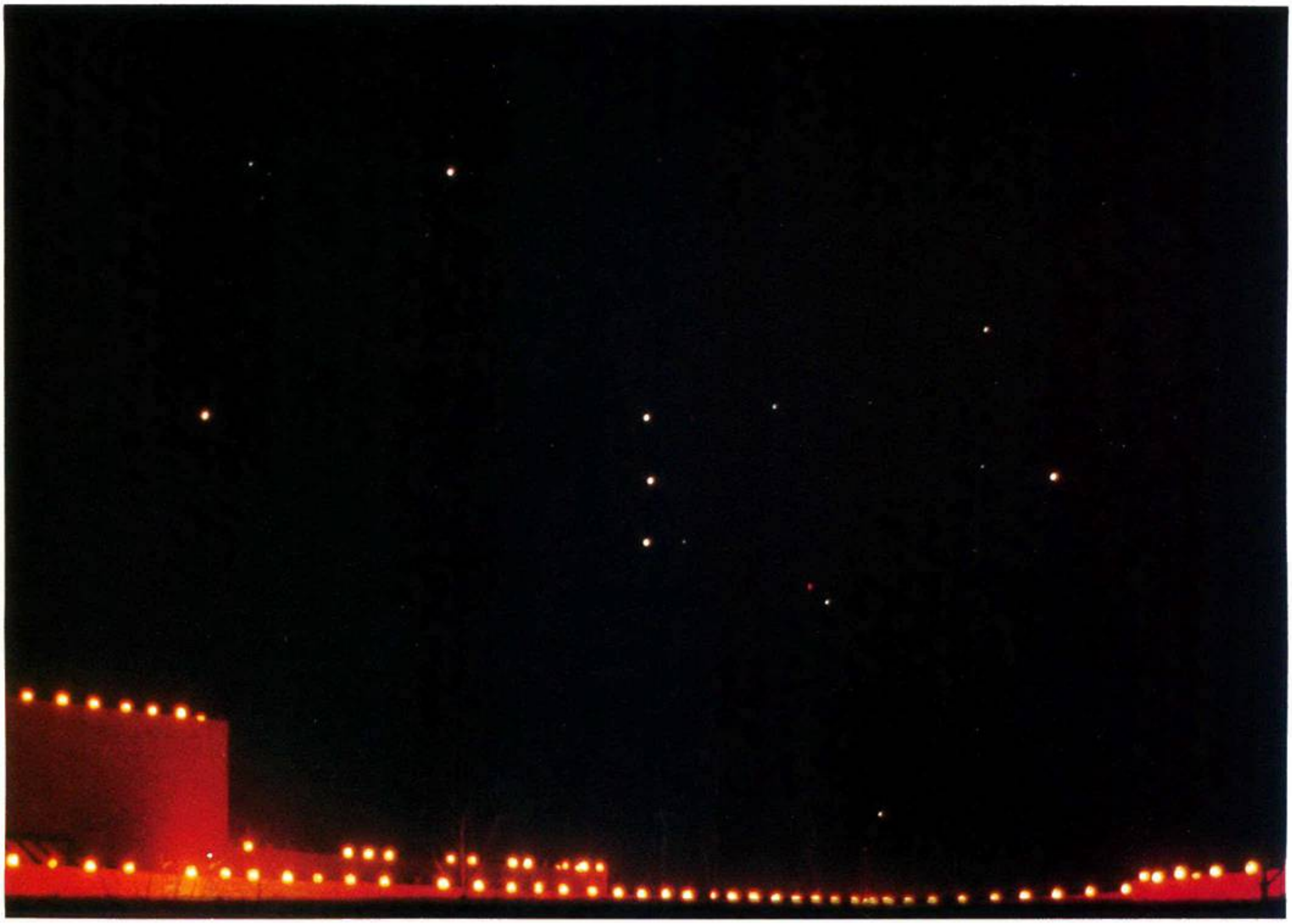
CYGNUS
M-27
DELPHINUS
LACERTA
M-15
EQUULEUS
Enif
PEGASUS
AQUARIUS
PISCES
Fomalhaut
SCULPTOR
● 1st magnitude and brighter
● 2nd magnitude
● 3rd magnitude
● 4th magnitude
○ clusters
◇ nebulae
⬭ galaxies

december sky almanac

2nd	The Moon is at perigee this morning: 223,797 miles.
7th	Last Quarter Moon is at 10:53 a.m. EST.
13th	Late tonight and early tomorrow morning is your best chance to look for Geminid meteors. From a dark-sky site, you can expect to see as many as 50 to 60 meteors per hour, but from urban and suburban locations, the rate will be far lower — 10 to 20 an hour at best.
15th	The Moon will be New at 4:18 a.m. EST. A partial solar eclipse will be visible in Europe, western Asia, and northeastern Africa.
17th	The Moon will be at apogee tonight: 252,437 miles.
18th	This evening the Moon is about to overtake Mars, which lies about 2 degrees north of it.
21st	Mars is at perihelion. The solstice is at 11:39 p.m. EST; winter begins officially in the northern hemisphere.
23rd	First Quarter Moon comes at 9:17 a.m. EST.
30th	The Moon is Full at 6:33 a.m. EST; there will be a total lunar eclipse — see text and Backyard Astronomer. Venus is at aphelion, Mercury is at greatest eastern elongation, and the Moon is at perigee (in the evening): 221,804 miles.



Last December, as Orion rose over the "luminarias" (candles in paper bags weighted with sand) that decorated the buildings at San Juan College in Farmington, New Mexico, Margaret Holliday and Meg McCalla photographed it with a 20-second exposure on ASA 200 film, using a lens set at f/2.8.

it and to the left, is **Mars**, another planet whose elongation is slowly decreasing. The Red Planet will be fainter than the first-magnitude star Fomalhaut, of the constellation Piscis Australis, which can be found well to the east of Mars.

Mars is at perihelion on the 21st — just nine days before Venus reaches aphelion, and not very long before Earth itself is at perihelion (January 2). Mars is still almost 40° from the Sun as the year ends, and will manage to elude the Sun until next June.

the starry sky

Much of the evening sky is still covered with the dim, winding, and intricate patterns of the "water constellations": **Capricornus**, **Aquarius**, and **Pisces**. But these aquatic groupings lie southerly in the sky and therefore exit the stage sooner than the other constellations of autumn. In December, the **Great Square of Pegasus** is definitely on its way down, though it still hangs relatively high in the west by mid-evening. And the brilliant forms of Perseus, Andromeda and Cassiopeia are even higher.

Coming before the magnificent constellations of winter are **Perseus** and the little star cluster of the Pleiades. The Milky Way runs narrow through Perseus, but here lie rich regions of faint stars for binocular sweeps or even naked-eye gazing from a dark rural site. The whole area of Perseus around the **Double Cluster** is thickly strewn with faint stars. Two other pretty star clusters are "possibles" for naked-eye looking: One is the bright and widely-spread association of stars around **Alpha** (α) **Persei**; the other is **M-34**, a fifth-magnitude open cluster best seen with low optical powers. It can easily be glimpsed by the naked eye as a glowing spot about halfway between Algol (Beta [β] Persei) and Gamma (γ) Andromedae.

Algol was one of the prime objects discussed last month; see if you can catch this famous eclipsing binary during one of its periodic drops in brightness from its usual 2.1 to 3.4 magnitude. The drop, the minimum, and rise to full light take about 10 hours in all and occur every 2.86739 days (2 days 20 hours 49 minutes).

Algol lies near the end of one of the branches of the Perseus pattern. The longer branch represents one of his legs, shod with a winged sandal; it points south to the prettiest cluster of them all, the unmistakable **Pleiades**. The six or seven brightest of these young blue stars form a tiny dipper with a close naked-eye pair — Atlas and Pleione — at the eastern end of the handle. Can you split them with your naked eye? They lie five minutes of arc apart; Atlas has a brightness of magnitude 3.6, and Pleione varies irregularly between 5.0 and 5.5.

The brightest star of the cluster is 2.9 magnitude Alcyone, and there are some 10 Pleiads brighter than the naked-eye limit, but their close proximity to each other makes "eyes only" identification of each very difficult — unless sky conditions (and your eyesight) are very good. Most observers commonly see six or seven Pleiads with the naked eye, and 12 is not impossible under exceptional conditions; a few observers claim to have spotted even more.

The Pleiades lie roughly 12° from a brighter cluster that is far more widely spread out and, hence, of less concentrated splendor. The brightest stars of this cluster, the **Hyades**, form a V which has at one tip first-magnitude **Aldebaran**, a foreground star not actually belonging to the cluster.

Orange-colored Aldebaran shines with an apparent magnitude as bright as all of the true Hyades combined, but in fact lies only half as far away. The Hyades and Aldebaran, which outline the face of **Taurus** the bull, fill a typical binocular field of view very nicely.

After looking with binoculars, examine the beautiful group closely with your naked eye. On good nights, you may be able to split two wide and bright doubles: **Theta^1** (θ^1) and **Theta^2** (θ^2) **Tauri**, magnitudes 3.9 and 3.3 with a 5½ arc-minute separation, and **Sigma^1** (σ^1) and **Sigma^2** (σ^2) **Tauri**, at magnitudes 5.1 and 4.7, with over seven arc-minutes of separation.

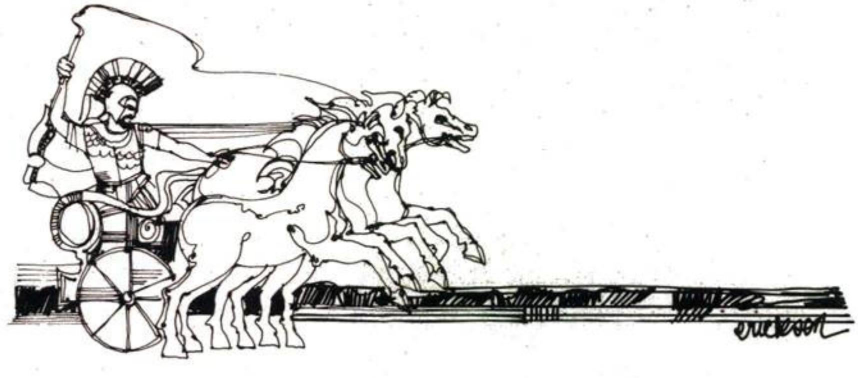
Another object in Taurus that often passes unnoticed is the variable star **Lambda** (λ). The "arrow" of the Hyades points conveniently south and west toward this star — one of several that form a kind of bridge to the tail of **Cetus** the whale. Lambda Tauri is an eclipsing binary that nearly approaches Algol in brightness and range; it varies from magnitude 3.4 to 4.1 in a period of just under four days.

On the other side of the Hyades — northeast of the cluster — we find the bull's horn-points, marked by dim **Zeta** (ζ) and bright **Beta** (β) **Tauri**. Beta, also called **El Nath**, officially belongs to Taurus, but is also used to form the prominent pentagon pattern of Auriga the charioteer.

The brightest star in **Auriga** is **Capella**, a Latin name meaning "little she-goat," given because this star represents the female goat held by the charioteer.

Just to the southwest of Capella are three stars of moderate brightness which have come to be known as **the Kids**, the offspring of Capella. The northernmost Kid, **Epsilon** (ϵ) **Aurigae**, is normally the brightest of the three, slightly exceeding Eta (η) Tauri in magnitude. But you will not find this true if you compare the two during December: Epsilon is an eclipsing binary and is undergoing one of its infrequent and lengthy eclipses. Currently, you should find it comparable in brightness to the third Kid, **Zeta** (ζ). Epsilon will be fading during all of December; we will take a closer look at it next month, when it reaches the beginning of its long minimum.

No sight in astronomy is more inspiring than the rising of **Orion** the hunter. Soon after Perseus, Auriga, and Taurus have become brilliantly prominent in the eastern sky, you can spot the red and blue fire of **Betelgeuse** and **Rigel** low in the east, with a nearly perfect line of bright stars extending vertically between them. Suddenly, it seems, the whole figure looms up over the skyline: Orion the hunter, replete with three-starred Belt and nebular-jeweled Sword, has finally arrived to usher in winter.



skylore

Among the famous mythological people in the December sky — Perseus, Andromeda and her family, Orion, the Gemini twins — there is one personage whose identification remains uncertain. The enigma is Auriga the charioteer.

There is one strong candidate for the identity of the human figure represented in the stars of Auriga, but this mythological person is not one of the better-known characters. He is Erechtheus, an early and legendary king of Athens. Scholarly debate about him has been greatly complicated because of confusion over his name and his place in the line of kings. For example, he may have been two different figures in legend: the fourth or fifth king of Athens and his grandson, the sixth or seventh king. According to this admittedly confused reckoning, it was the grandfather — Erechtheus I — who became memorialized in Auriga. A further confusion is that both Erectheus I and II are sometimes called Erichthonius, a name that belonged also to a king of Dardania who owned 3,000 of the world's swiftest horses, bred of the North Wind.

The conception and childhood of Erechtheus I were strange even by the standards of Greek mythology. The story goes that Poseidon tricked Hephaestus, the lame blacksmith of the gods, into thinking that Athena wanted the smith to make passionate love to her. When the chaste Athena arrived to check on some business with Hephaestus, he attempted to ravish her. The goddess was able to resist his attack, but during the encounter Hephaestus "spilled his seed" — which fell from heaven to fertilize Gaia (Earth).

The baby which Gaia bore was Erechtheus, but even this most generous matron refused to take care of a child so ill-conceived. Athena, however, took pity and raised Erechtheus — though in secret, so that her adversary Poseidon would not find out and mock her.

While Erechtheus was still an infant, Athena put him in a basket and entrusted him to the care of the three daughters of Cecrops (whom many authorities claim was the second king of Athens). These girls were named Agulauros, Herse, and Pandrosos. Several tales are told about their fates, but according to one with a bearing on our story, two of the girls disobeyed Athena's strict order not to look in the basket. Although Pandrosos resisted the urge to peek, the others gazed in and saw an infant who appeared to be wrapped in a snake's coils — which in reality was the snake-tail of the deformed Erechtheus. They were instantly seized with madness at the horrible sight and flung themselves to their deaths from the top of the Acropolis.

After Erechtheus had grown up in the care of Athena, he became king of Athens by unseating Amphictyon, who, incidentally, was the first to name the city Athens. It is also said of Erechtheus that he initiated the worship of Athena and was the first to teach men the art of working silver. Perhaps an even greater accomplishment was his (legendary) invention of the chariot, for which — at last, the point of the whole story — he has been identified as the figure of the charioteer in the starry heavens.

But there are many other claimants for the title of Auriga. Among the most interesting are those of Phaethon, who drove the chariot of the Sun one day with disastrous results, and Bellerophon, who rode Pegasus when he went to kill Chimera, a three-headed monster.

Actually, the celestial figure of a man in a chariot or wagon, or of a chariot alone, seems to antedate the classical Greeks and to have been adopted by them from the Middle East. In his book *Star Lore*, Richard Allen mentions the claim that the Egyptians knew the constellation as Roh, a wagoner, or Lora, the reins, but does not discuss how early these titles may have come into use.

The commonest representation of Auriga does not include the chariot, but does include the mother goat, Capella, and her kids, which the charioteer is holding. Their stories will be told in an upcoming Eye on the Sky.

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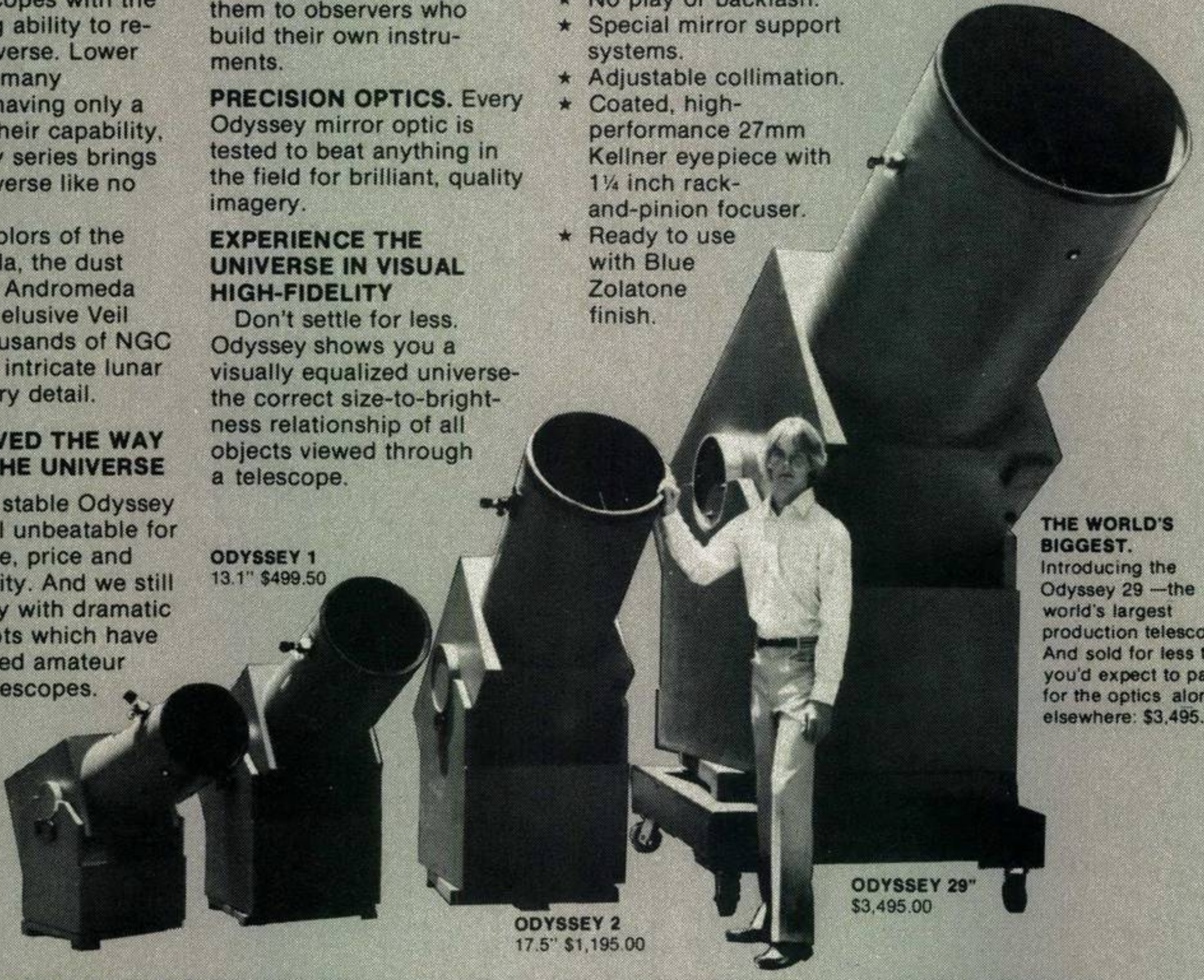

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a year's harvest of pictures

photography in astronomy

Only a handful of pictures of sky events have come down to us from all the ages before the twentieth century. Among them, we remember the Bayeaux tapestry's image of Comet Halley; the images pecked into rock surfaces depicting, debatably, a prehistoric supernova near the crescent Moon; and perhaps, at best, a few dozen more.

In our century, photography has placed the ability to record events into the hands of virtually any human being — images that can stir the imagination, evoke memories, or enrich our lives with events that we could never hope to see with our own eyes. Think of all the things you might not know about if you had not seen pictures.

But photographing is not the same as seeing. Photography can extend our vision to objects fainter than we can see by eye, add light to build up images of events that never happened, record incredible detail in a fraction of a second.

So photography brings us closer to reality when it captures the dim glow of a planetary nebula, brings out the Earthshine on the unlit side of the Moon, links time and motion through star trails and multiple exposures, reveals hidden solar structure, and maps the Moon more crisply than the skilled hand and eye of an artist.

We can all photograph. And we must remember that cameras, film, and filters, though vital, remain less important than the perceptive eye and inquiring mind of the photographer.

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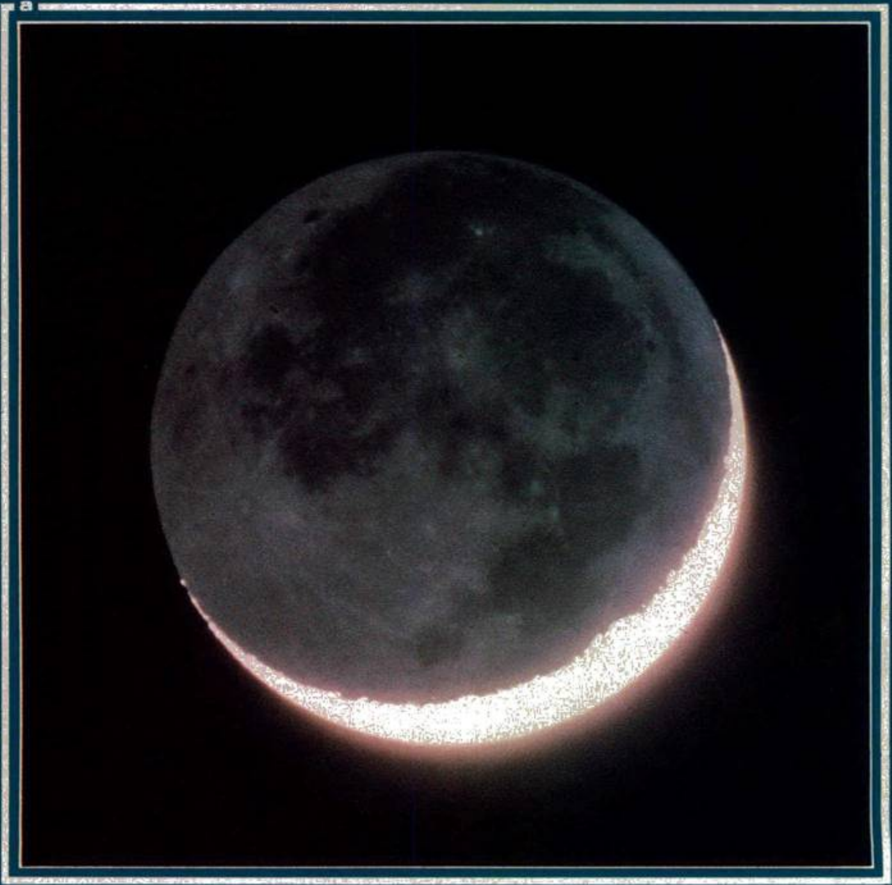

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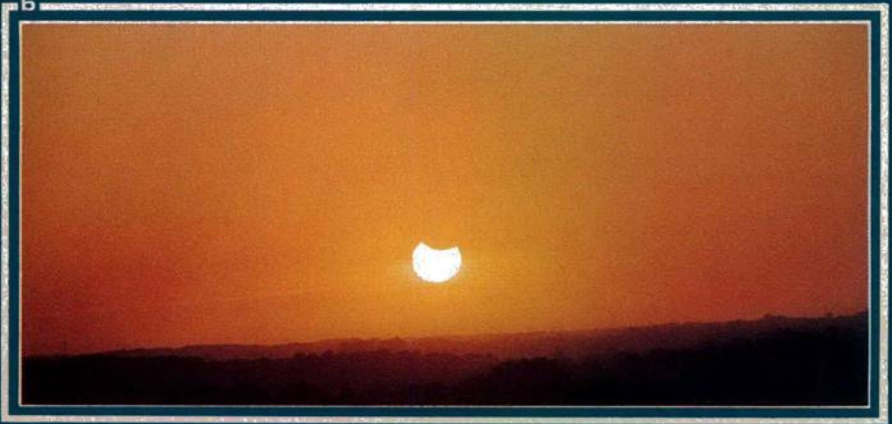
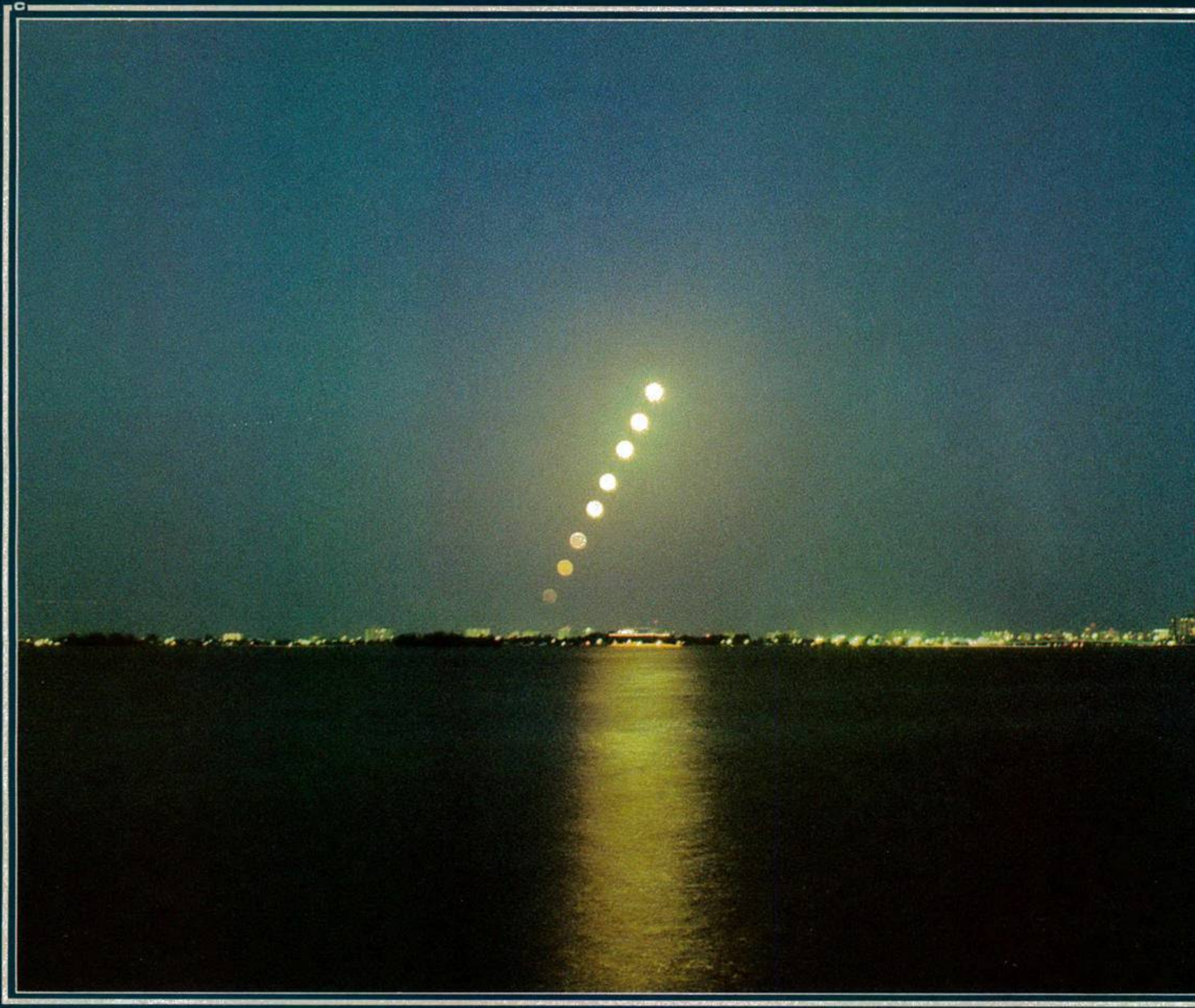
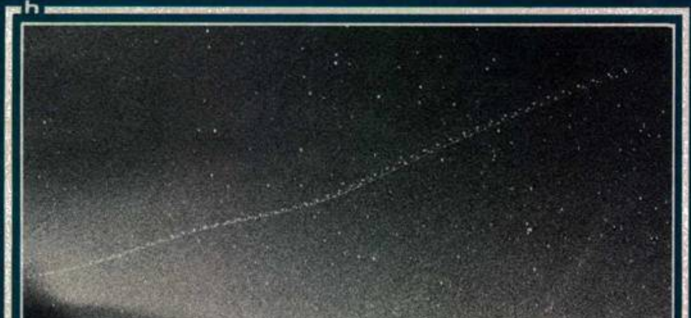


a: Kerry Hurd captured this superb view of earthshine on the Moon using his 10-inch f/6 reflector and a 5-second exposure on Fujichrome 100 emulsion. **b:** On July 20, a partial solar eclipse was visible from western Europe (see also photo **m**). From Denmark, Karl Kruhoeffer photographed the event with a 200mm f/4.5 telephoto lens. The $^{1}/_{1000}$-second exposure was made on ASA 100 film.





c: Astrophotographer Paul Missal created this view of the Full Moon rising over Miami Beach by opening his camera's shutter for 10 seconds once every 10 minutes. He used a 35mm f/2.8 lens and Ektachrome 200 film, which was "pushed" to ASA 400. **d:** Rarely observed and almost never photographed, planetary nebula NGC-6781 in Aquila was recorded by Jack Newton, who used a 16-inch f/5 Newtonian, chilled Ektachrome 400 film, and an exposure of 18 minutes. **e:** Magnificent Saturn remained easily accessible to skywatchers until late in the year, when it disappeared into the evening twilight. Jeff Beish made this photograph of the giant ringed planet. **f:** The big event of the year for observers was the total lunar eclipse of July 6. As the Earth's shadow crept across the Moon's surface, Jean Campbell used her 80mm f/4.5 lens to make a time exposure of the event. **g:** Huge trees stand in the foreground of John Foster's stationary-camera portrait of circumpolar star trails. **h:** Comet Austin (1982g) flashed into the northwestern sky in early August and, at 4th magnitude, became the brightest comet since Comet West in 1976. Using a 4-inch f/5 camera, 098 emulsion, and a #1A filter, Ronald Royer took this one-hour exposure of Austin in mid-August. The wobbly line above center is an airplane trail. **i:** Ruth Suarez captured the reddish hue of an aurora last April from Othello, Washington. She put her camera, loaded with ASA 100 film and outfitted with a 28mm f/2.8 lens, on a tripod and opened the camera's shutter for 6 minutes. **j:** Jules Vieiru photographed the lunar terminator using an 8-inch Schmidt-Cassegrain at f/60 and Plus-X emulsion.

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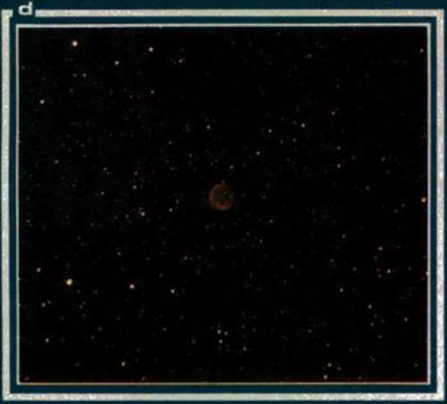

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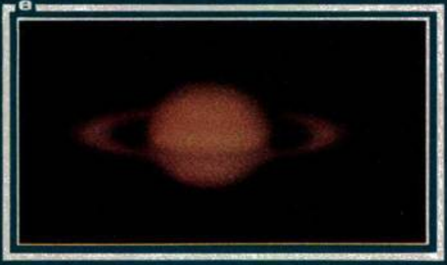

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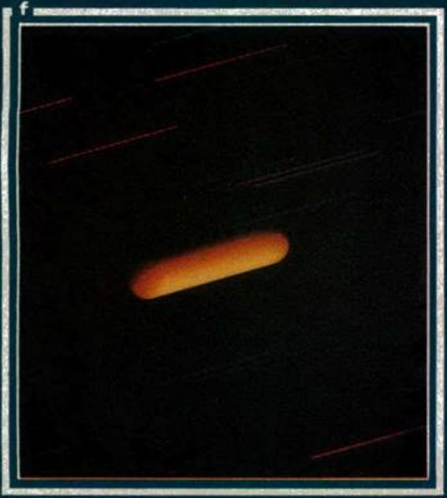

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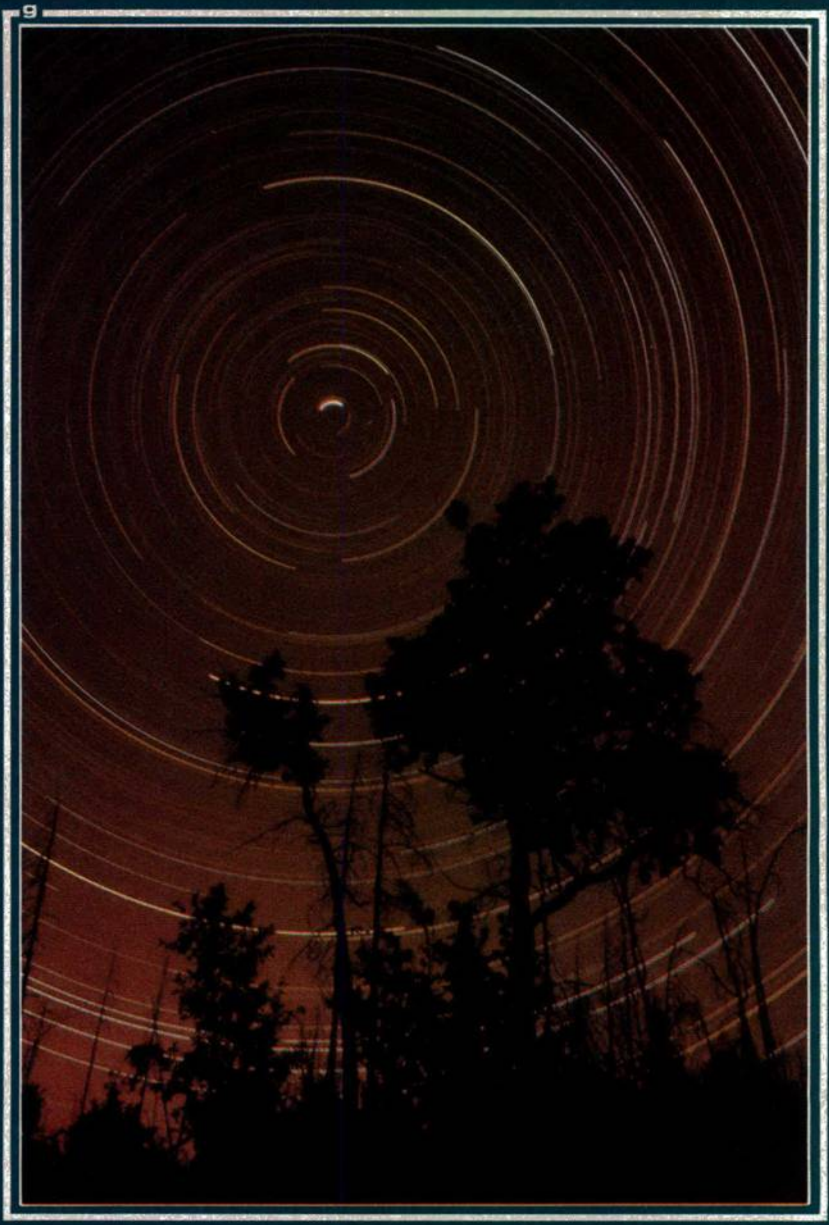

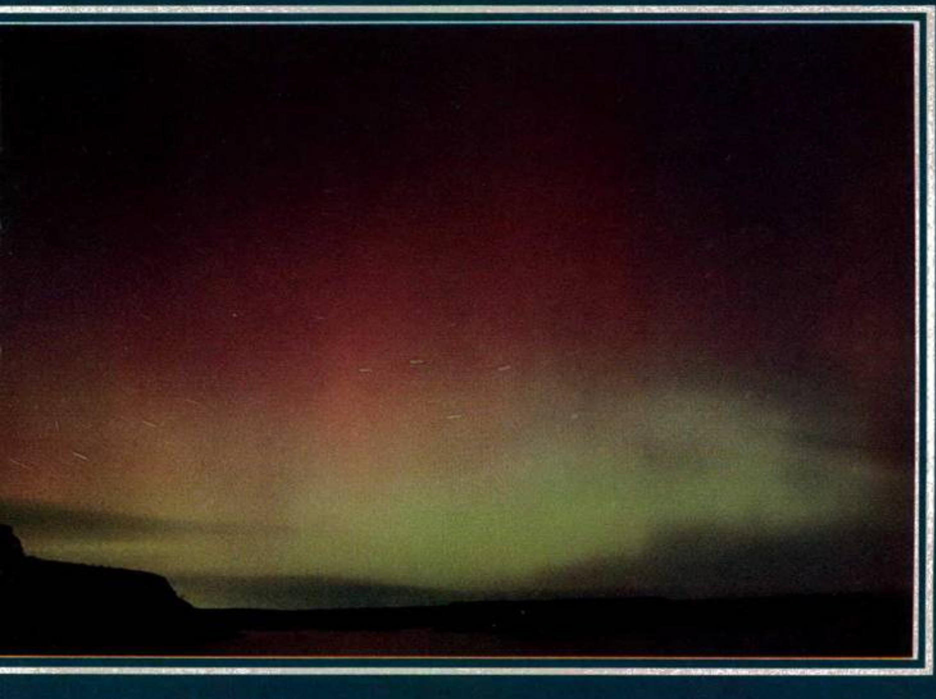

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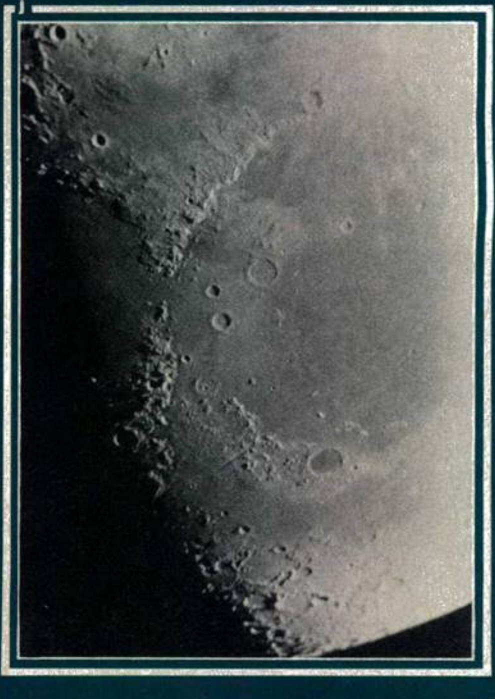

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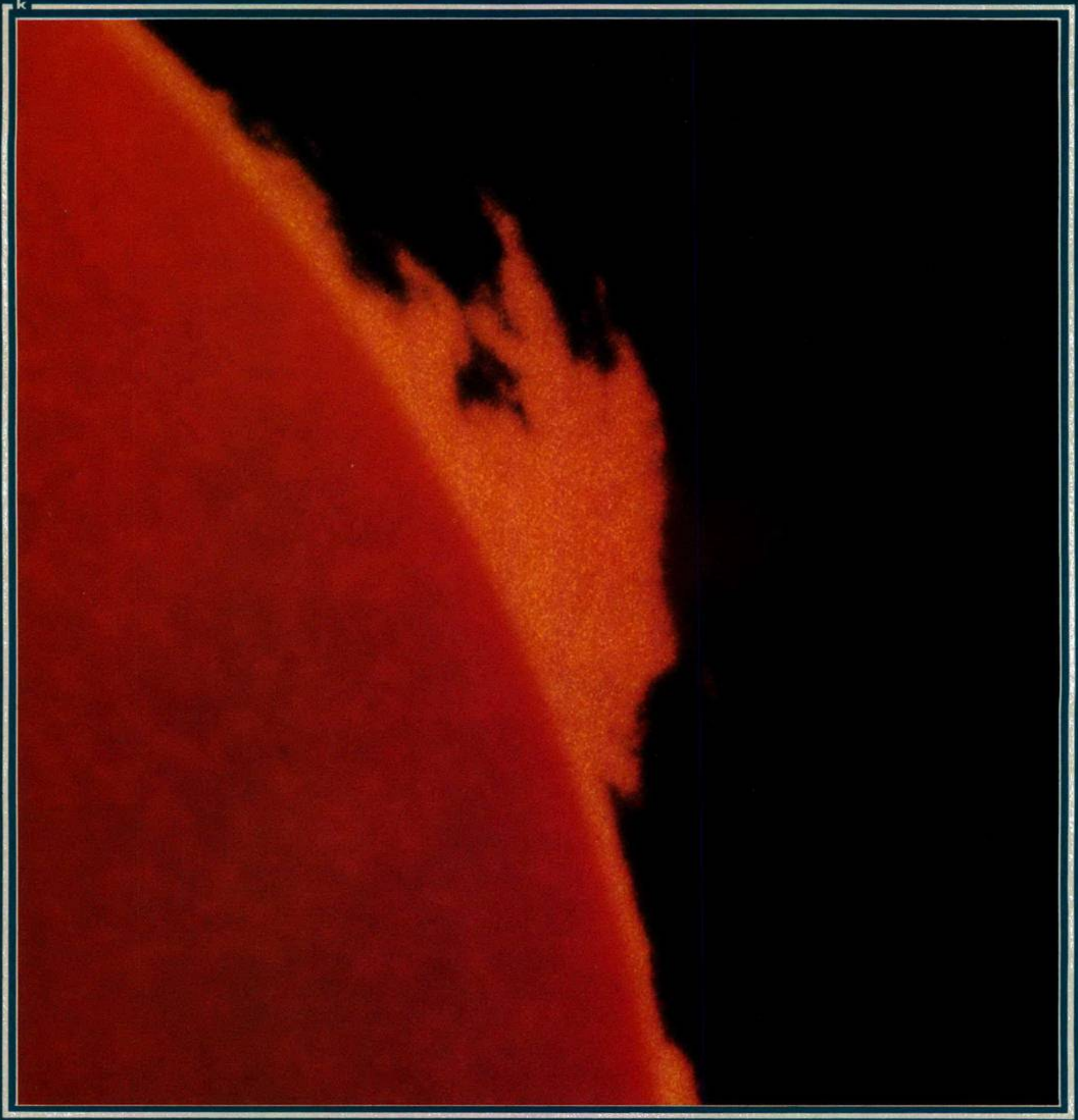

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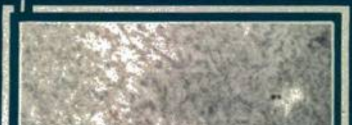

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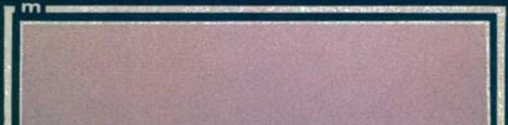

three looks at the sun:

k: This composite photograph shows the breathtaking potential of solar photography. John Hicks sandwiched a color negative of the prominence with a black-and-white negative of the solar disk, and rephotographed them onto color slide film. The two original negatives were made with an 8-inch Schmidt-Cassegrain. **l:** This photo illustrates our star's surface as viewed in hydrogen-alpha light. Using a 3.5-inch scope at f/30 and Technical Pan 2415 film, Randy Tatum captured a nice cluster of sunspots and associated faculae. **m:** Olivier de Goursac obtained this fine shot of the solar eclipse visible from western Europe on July 20 by climbing the Montparnasse Tower in Paris. He used a 50mm lens and Ektachrome 64 film.

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16″ Equatorial Reflector: **$1185.00**, complete! The Giant-Aperture, Deep-Space Telescope You Never Thought You Could Afford… Until Now

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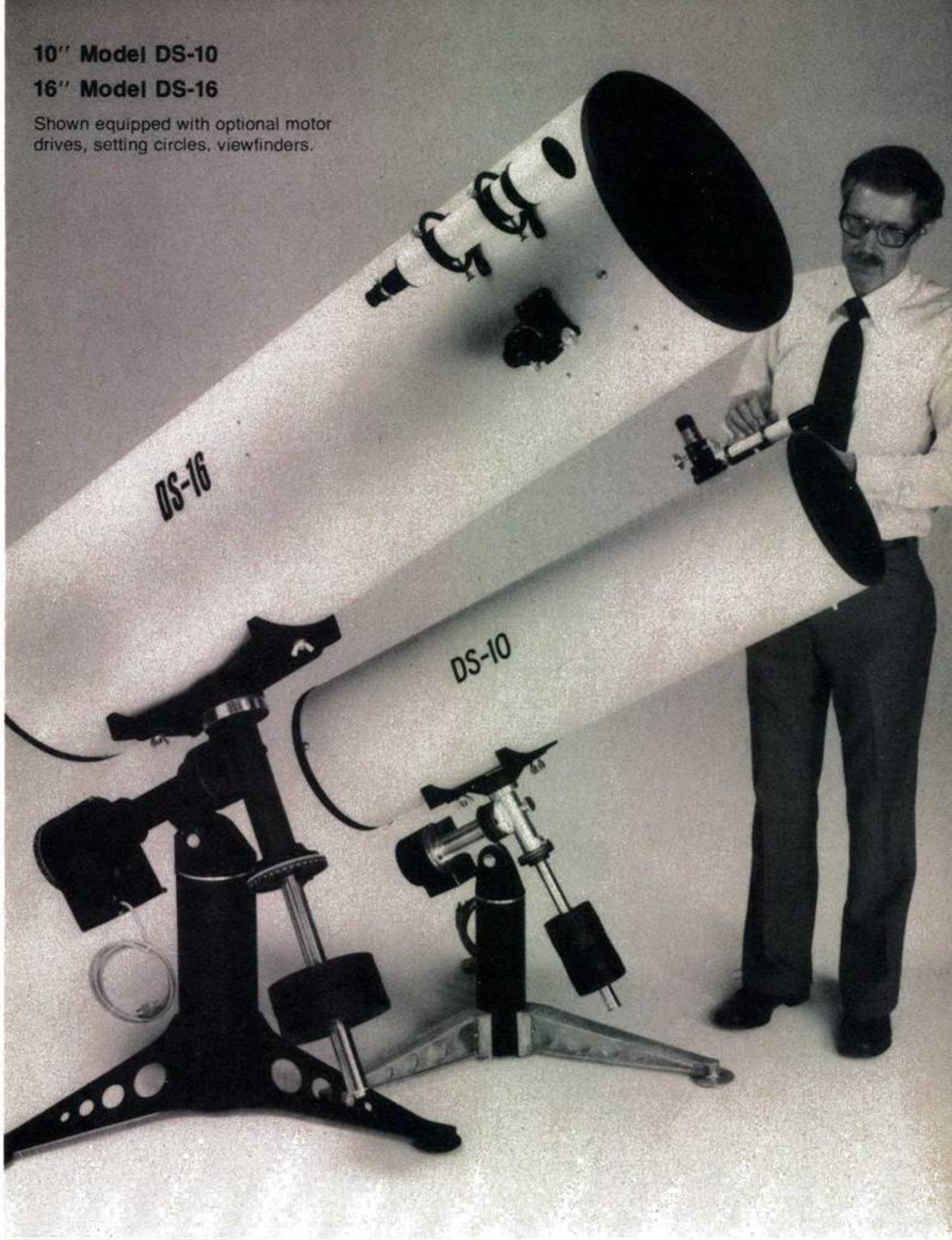
Manufactured exclusively for Crown Optics by Meade Instruments Corp., the World's largest manufacturer of reflecting telescopes for the serious amateur, the DS-10 and DS-16 make available to the average amateur visual and photographic capabilities only dreamed of until now. Unlike competing large-aperture telescopes, the Meade DS-Series Telescopes include **Equatorial Mounts** as standard equipment: you track effortlessly along **one** axis, not along 2 simultaneous axes as with an alt-azimuth mounting. Add the optional Electric Motor Drive System and you're ready for fully automatic tracking and the deep-space photography you never thought possible.

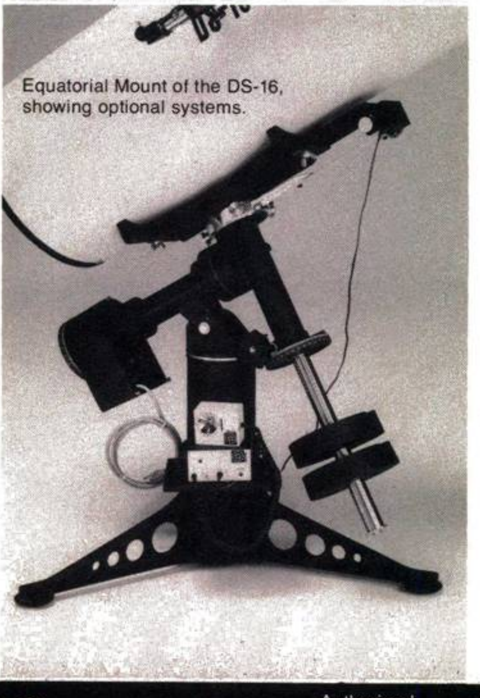
SPECIFICATIONS— Meade DS-10: 10″ f/4.5 Reflecting Telescope. With null-figured, diffraction-limited Pyrex parabolic primary mirror and matching (2.60″ M.A.) 1/10-wave flat elliptical secondary; #67 rack-and-pinion focuser at convenient observing position; Kellner 25mm (46×) eyepiece; Sonotube 12″ I.D. × 46″ long, sealed and attractively Zolatone coated; all-metal, precision-machined Equatorial Mount, with ultrasmooth nylon bearings and 1″ solid steel shafts; rock-solid, low-profile pier and tripod legs; locks on both axes. Complete: **$449.50**.

SPECIFICATIONS— Meade DS-16: 16″ f/4.5 Reflecting Telescope. With null-figured, diffraction-limited, Pyrex parabolic primary mirror and matching (4.00″ M.A.) 1/10-wave flat elliptical secondary; flotation mirror cell; #67 rack-and-pinion focuser at convenient observing position; Kellner 25mm (73×) eyepiece; Sonotube 18″ I.D. × 68″ long, sealed and attractively Zolatone coated; all-metal, precision-machined Equatorial Mount, with ultrasmooth Nylon bearings, 1½″ solid steel shafts, and 5″-dia. polar thrust surface; rock-solid, low-profile pier and tripod legs; locks on both axes. Complete **$1185.00**.



10″ Model DS-10
16″ Model DS-16

Shown equipped with optional motor drives, setting circles, viewfinders.



Equatorial Mount of the DS-16, showing optional systems.

OPTIONAL SYSTEMS

# 787	**Electric Motor Drive System (115v./60Hz) for DS-10**	**$ 60.00 ppd.**
# 897	**Electric Motor Worm-Gear Drive System (115v./60Hz) for DS-16**	**155.00 ppd.**

See our ad on the next page for the wide array of other optional accessories for the DS-10 and DS-16. These include: higher- and lower-power eyepieces; viewfinders; telenegative amplifiers; nebular filters; drive correctors and photoguide telescopes for long-exposure photography; camera adapters. The giant Meade #680 Focuser may also be ordered *in place of the standard* focuser on the DS-10 and DS-16. See Bulletin DS for details.

- Both models are **complete** instruments at the prices listed— no additional parts or accessories required to start observing.
- Easy Portability— Field set-up time is about 2 minutes for the DS-10, 5 minutes for the DS-16.
- The DS-10 and DS-16 carry the Meade Full-Year Limited Warranty.
- **Prompt shipment** on both models— Order by mail, or by dialing the Crown TOLL-FREE 800-number. (See next page for details.)
- All prices include packing; F.O.B. Costa Mesa, Calif.
- Delivery direct to your door by U.P.S. or truck freight.
- Send for **Free Bulletin DS,** with full details on these incredible deep-space telescopes, or enclose $3.00 for complete General Catalog of Meade astronomical products. (See next page for details.)

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1— **Model 300PG:** D=80mm (3.1"); F=1200mm (f/15) **$185.00 ppd.**
2— **Model 280PG:** D=60mm (2.4"); F=700mm (f/11.7) **79.50 ppd.**
3— **Model 210PG:** D=50mm (2.0"); F=600mm (f/12) **57.50 ppd.**
Mounting Rings: for #210PG .... per. pr. **9.75 ppd.**
for #280PG, #300PG ..... per. pr. **12.50 ppd.**

RACK-AND-PINION FOCUSERS— All 3 models include helical-cut rack and variable-tension adjustment for ultra-smooth focusing without backlash. Universal bases fit all tube sizes. Standard 1¼" eyepiece holders.

4— **Model 67** — Strong, lightweight design for 4" to 10" telescopes. 2-3/16" travel. An excellent value. **$23.50 ppd.**
5— **Model 640** — A heavy-duty deluxe focuser for 6" to 16" telescopes. Full 3" travel for both visual and photographic applications. **$36.95 ppd.**
6— **Model 680** — Accepts both 1¼" and 2" eyepieces. Full 3" travel for photo or visual observing with 6" to 16" telescopes. **$44.95 ppd.**

ACCESSORY CASES— For secure storage of eyepieces, Barlows, filters.

7— **Model 54**: Thick-wall polyethylene with latch and handle. Holds 7 eyepieces & Barlow, filters. Dims. 12" × 8" × 3¾" **$12.50 ppd.**
8— **Model 50:** Luggage-quality metal case with 2 latches, handle; foam custom fits to your accessories. Dims. 20" × 12" × 6½" .... **$39.50 ppd.**

NEBULAR FILTERS—Revolutionary 3-channel filters block natural airglow & sodium and mercury emissions from city lights. Dramatically improve telescope performance visually and photographically.

9— **Model 907:** 18mm aperture, for .965" O.D. eyepieces **$42.50 ppd.**
10— **Model 908:** 23mm aperture, for 1¼" O.D. eyepieces **$49.95 ppd.**
11— **Model 911**: 36mm aperture, threads directly onto rear-cell of Meade and Celestron Schmidt-Cassegrains. .... **$69.50 ppd.**

12— **PHOTO-VISUAL COLOR FILTERS**— Top quality optical glass, dyed-in-the-mass, with excellent spectral homogeneity. Thread directly into 1¼" O.D. barrels. Filters may be piggybacked. **#8 Light Yellow—#11 Yellow-Green—#12 Yellow—#21 Orange—#23A Light Red—#25A Red—#47 Violet—#58 Green—#80A Blue—Polarizer (30% transmission).** Each filter: **$7.50 ppd.** Set of any 6: **$43.50 ppd.**— Full set of 10: **$70.00 ppd.**

13— **VARIPAK DRIVE CORRECTOR—Model 43:** Supercompact 2" × 3" × 4" design. Fast-slow pushbuttons. Variable speed control. Operates from 12 volts D.C., plugs into standard auto cigarette lighter. The 12-watt output is sufficient for most telescopes to 14" aperture .... **$59.50 ppd.**

14— **VARIGUIDE DRIVE CORRECTOR— Model 41:** The finest R.A. drive corrector available. Includes aircraft-type joystick controller for continuously variable correction rates. Variable speed control. Use with any telescope drive rated up to 12 watts. Operates from 12 v. D.C. or 115 v. A.C. **$110.00 ppd.**

15— **6 × 30mm VIEWFINDER—Model 631:** Same unit supplied as standard equipment on Meade 6" and 8" reflecting telescopes. Actual field: 4°. Includes coated, achromatic objective lens and crosshair eyepiece. Precise push-pull focusing. Thousands now in use. Bracket, with collimation screws and lock-nuts, included. Bracket fits all tubes 6" to 12½". **$24.50 ppd.**

16— **6 × 30mm RIGHT-ANGLE VIEWFINDER— Model 633:** As in (15), but with prism for convenient right-angle observations. Prism may be rotated 360° for maximum viewing comfort. 2-ring bracket included. **$29.50 ppd.**

17— **SERIES 1 KELLNER EYEPIECES (1¼" O.D.)**—High-quality, fully-coated optics housed in chromed barrels threaded for filters. Sold elsewhere for $18.00 to $22.00. **KE 9, 25, 40mm** .... each **14.75 ppd.**

18— **SERIES 1 ORTHOSCOPIC EYEPIECES (1¼" O.D.)**— Well-corrected 4-element designs, fully coated, threaded for filters. Sold elsewhere for $26.00 to $30.00. **OR 4, 6, 9, 12.5, 25mm** .... each **$23.75 ppd.**

19— **SERIES 2 MODIFIED ACHROMATIC EYEPIECES (1¼"O.D.; MULTI-COATED)**—Custom 3-element designs, precisely corrected for chromatic and spherical aberrations. Finest obtainable under $20.
FOCAL LENGTHS: MA 6,9,12,25mm, 40mm Wide-Field, ea. $18.95 ppd.

20— **MODIFIED ACHROMATIC 40mm EXTRA-WIDE-FIELD EYEPIECE (1¼" O.D.; MULTI-COATED)**—Yields widest field obtainable in 1¼" O.D. Enlarged field lens and special field-flattening optics with long eye relief. **$27.50 ppd.**

21— **SERIES 2 ORTHOSCOPIC EYEPIECES (1¼" or .965" O.D.; MULTI-COATED; PARFOCAL)**— The excellent 4-element high resolution optics of these oculars are all the majority of serious amateurs ever require. Razor sharp 45° fields. Both 1¼" and .965" O.D. sets parfocalized.
FOCAL LENGTHS: OR 4, 6, 9, 12.5, 18, and 25mm .. each $27.50 ppd.

22— **RESEARCH-GRADE ORTHOSCOPIC EYEPIECES (1¼" O.D.; MULTI-COATED; PARFOCAL)**—The largest selling premium-quality eyepieces in the world, universally acclaimed to be the finest eyepieces obtainable. 4-element systems, unsurpassed in color correction, resolution, and flatness of field. 45° field. **OR 4, 7, 10.5, 16.8, 28mm** .... **each $42.50 ppd.**

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FOCAL LENGTHS: ER 7, 12.4, 15.5, 20mm .... **each $47.50 ppd.**

VIEWFINDERS— With helical focusers for ultraprecise control of image sharpness. Coated, achromatic objectives of new Meade design yield fully corrected images throughout the field. Actual field on 50mm models: 4¼°; on 60mm models: 3½°. Crosshair eyepiece, dewcap, dustcap included.

24— **8×50mm— $46.50 ppd.** Brackets: **$9.75/pr. ppd.**
25— **8×50mm RIGHT-ANGLE— $53.50 ppd.** Brackets: **$9.75/pr. ppd.**
26— ***GIANT* 9×60mm— $65.00 ppd.** Brackets: **$12.50/pr. ppd.**
27— ***GIANT* 9×60mm, RIGHT ANGLE— $71.50 ppd;** Brackets: **$12.50/pr.**

28— **RESEARCH-GRADE ERFLE 32mm EYEPIECE (2" O.D.; MULTI-COATED)**—Wide-angle, fully-corrected 65° field. The finest eyepiece obtainable in 2" barrel. **$99.50 ppd.** Adapter Barrel for 1¼" O.D. **$10.75 ppd.**

29— **DELUXE CAMERA ADAPTERS**— Adapt your camera to telescope focuser instantly. Individually machined from solid bar aluminum and brass. All units permit both eyepiece-projection and first (prime) focus photography. Specify your camera brand and either 1¼" or .965" focuser. All 1¼" units are threaded for filters. **Nikon, Canon, Minolta, Pentax K, Konica, Olympus OM, or Universal Thread-Mount** .... **$29.50 ppd.**

30— **2X and 3X TELENEGATIVE AMPLIFIERS (1¼" O.D.; MULTI-COATED)**— Warranted without qualification to be the world's finest Barlow lenses. Full 26mm clear apertures, Multi-Coated, with virtually flawless optical corrections at all photo-visual wavelengths on any telescope. **2X Model 122: .. $29.50 ppd.; 3X Model 123: . . . $32.50 ppd.; 2X Model 131**: Per Model 122, but for .965" focusers; 18mm clear aperture, Multi-Coated. **$22.50 ppd.**

31— **2X-3X VARIABLE TELENEGATIVE AMPLIFIER (1¼" O.D.; MULTI-COATED)— Model 127**: Made to same research standards as Model 122 above, but mounted in a machined sliding cell, for variable power settings between 2X and 3X. Engraved scale indicates power. Multi-Coated . . . **$39.95 ppd.**

32— **PARABOLIC MIRRORS**— The very finest. 1/10-wave, diffraction-limited primary mirrors. Aluminized and quartz overcoated. Immediate shipment. **6"f/8 . . . $65.00 ppd.; 6" f/5 . . . $75.00 ppd.; 8" f/6 . . . $95.00 ppd. 10" f/6 . . . $195.00 ppd.; 12½" f/6 . . . $335.00 ppd.**

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34— **ILLUMINATED RETICLE GUIDING EYEPIECE (1¼" O.D.)**— New phosphorescent etched double-line reticle permits line illumination from dim to extremely bright. Remote brightness control and 6 ft. cable. Modified Achromatic 12mm optical system. Precisely focusable reticle. Complete . . . **$49.95 ppd.** Interchangeable barrel for .965 " O.D. . . . **$7.50 ppd.**

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36— **ERECTING PRISMS**— Fully coated Porro prisms. Invert the astronomical image for terrestrial observations with astronomical telescopes. **1¼" O.D. . . . $29.75 ppd.; .965" O.D. . . . $25.75 ppd.**

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39— **Model 918**: 18mm clear aperture. Fits 1¼" focusers, accepts 1¼" eyepieces .... **$22.95 ppd.**
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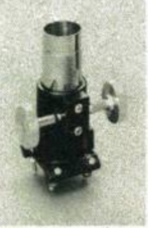
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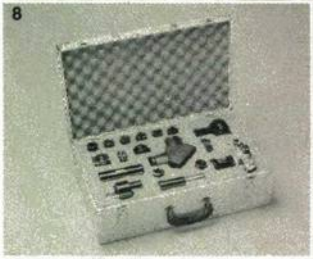
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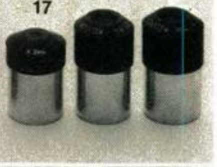
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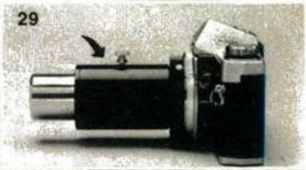
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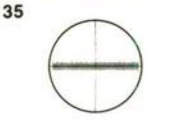
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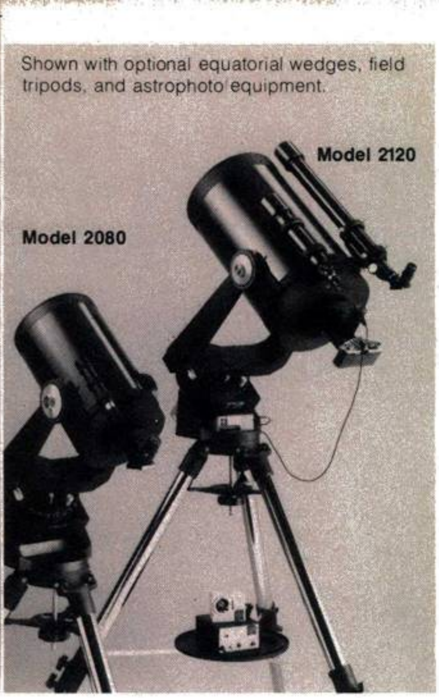
Meade Model 2080:
8″ Schmidt-Cassegrain

Meade Model 2120
10″ Schmidt-Cassegrain



Shown with optional equatorial wedges, field tripods, and astrophoto equipment.

Research-Quality Accessories for Meade and Celestron Schmidt-Cassegrains

All of these Meade accessories are of the finest optical and mechanical quality available, and all (except item H) may be used interchangeably on Meade and Celestron Schmidt-Cassegrains.

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A—	**Off-Axis Guider Body**	$45.50 ppd.
B—	**T-Adapter**	19.00 ppd.
C—	**Tele-Extender**	19.00 ppd.
	T-Rings (specify camera brand)	each 10.00 ppd.
D—	**Telecompressor Lens** (f/5), Multi-Coated	37.50 ppd.
E—	**Extender Tube** (to use Telecompressor with Off-Axis Guider)	11.50 ppd.
F—	**Wide-Field Adapter Systems** (Visual Telecompressors) Includes Telecompressor Lens, Special T-Adapter, and Diagonal Prism.	
	For .965″ eyepieces	71.50 ppd.
	For 1¼″ eyepieces	77.50 ppd.
G—	**2″ Diagonal Mirror.** Includes adapters for 1¼″ and 2″ O.D. eyepieces	159.95 ppd.
H—	**Dual-Axis Drive Corrector, Model 46**—Attaches in 2 minutes to Meade Models 2080, 2080C or 2120. No drilling required. Includes R.A. drive corrector, Dec. motor and clutch system, joystick controller. Operates from 115v. /60Hz or 12v.D.C.	219.50 ppd.
I—	**Solar Filters**—Optical glass, Inconel-coated, for professional-level solar observation. For Meade 2080 or Celestron 8.	
	#955: 8″ Full-Aperture Solar Filter	165.00 ppd.
	#956: 3″ Off-Axis Solar Filter	90.00 ppd.
J—	**Series 6 Drop-In Filters** (not shown). Optical glass. Includes Pink, Yellow, Yellow-Green, Red, Blue, Neutral (0.6). Set of 6 filters	35.00 ppd.

For Nebular Filters, Thread-In Filters, Drive Correctors, Barlow Lenses, Illuminated Reticle Eyepieces, and Erecting Prisms, see the accessories listing on the facing page. These accessories are fully compatible with Meade and Celestron Schmidt-Cassegrains.

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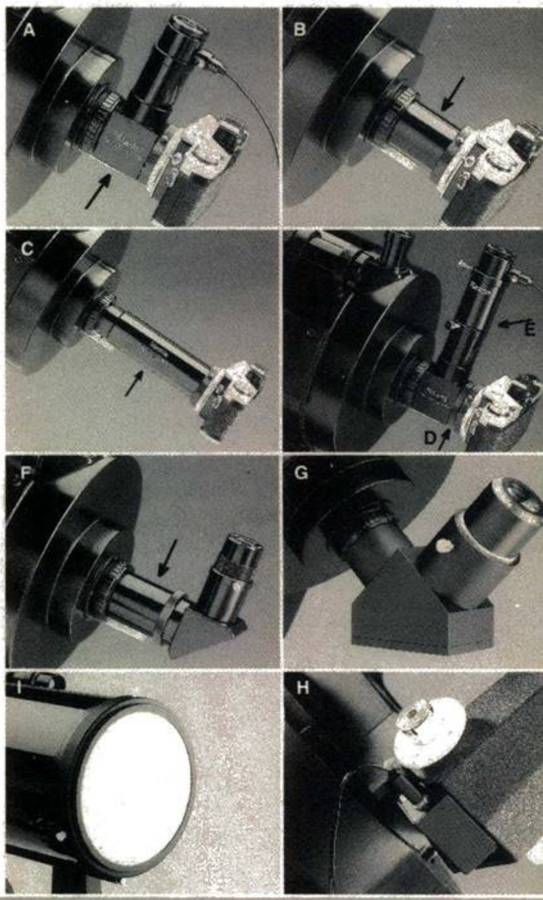

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ASTRO NEWS

International Halley Watch Organized

An international network of scientists and amateur astronomers is being organized to observe Comet Halley when the comet passes Earth in 1986. The International Halley Watch (IHW) will be led by Ray Newburn, cometary science team leader at Caltech's Jet Propulsion Laboratory in Pasadena, California, and Jurgen Rahe, the director of Remeis Observatory of the University of Erlangen-Nurnberg, Erlangen, Federal Republic of Germany.

The IHW invites all Comet Halley observers, professional or amateur, to share their data with the IHW networks now being created. IHW will collect ground-based observations as well as those of balloon, airborne, and Earth-orbital instruments. The data compiled will form the Halley Archive, the largest collection of information ever produced on a single comet.

Lick Observatory

Japan, the Soviet Union, and the European Space Agency are each sending spacecraft to encounter the comet in 1986, and plan to supply their scientific results to the Halley Archive.

Experiment teams supported by the IHW will study the comet using seven general techniques:

- Large-scale phenomena studies will use wide-angle photography to study the comet's tail.
- Near-nucleus studies, using high-resolution photographic and electronic imaging of the coma, will yield data on the nucleus, its rotation rate, surface structure, and the comet's general activity.
- Spectroscopy and spectrophotometry will provide data on the physical composition of the nucleus, coma, and tail.
- Photometry and polarimetry will determine the abundances and distribution of volatile and non-volatile components of the coma and tail.
- Radio science experiments will study the chemical composition and kinematics, or motion, of the coma, nucleus, and tail, searching for chemical species not discernible in optical wavelengths. Radio experiments will also detect thermal emissions from solids and perform studies of plasmas.
- Infrared spectroscopy and radiometry will determine the temperature, size, and composition of dust particles released by the comet. Gaseous components may also be identified.
- Astrometric observation — studies of Halley's position in relation to stars — will provide information on the comet's orbit and ephemeris. The observations will also help determine what effect outgassing of ice from the nucleus has on the comet's velocity.

The leaders of the IHW hope to coordinate the efforts of amateur observers with those of professionals in the following specific ways: Amateur visual and photographic observations will be compared with those of the 1910 apparition of Halley. Spectroscopy and photoelectric photometry of the comet obtained by amateurs can provide supplementary coverage of Halley in case of bad weather at major observatories. And finally, amateur studies of meteors during the Halley apparition will be especially helpful, since few professional astronomers devote time to meteor observations. (The Eta Aquarid meteor shower in May 1986 and the Orionid Meteor shower in October of the same year are believed to originate from Comet Halley.)

Amateur observers interested in joining the International Halley Watch should write to Steve Edberg, Mail stop T-1166, Jet Propulsion Laboratory, Pasadena, CA 91109.

Conestoga 1 Lifts Off

A Houston-based firm was successful on September 9 in a second attempt to launch a privately-funded rocket from an island just off the Texas coast.

Powered by a solid-fuel surplus Minuteman I second-stage booster, the Conestoga I reached an altitude of 195 miles during its 10.5-minute flight. No attempt was made to recover the rocket or its payload — 332 pounds of water — which plunged into the Gulf of Mexico about 326 miles from its Matagorda Island launch site.

According to David Hannah Jr., chairman of Space Services Inc., the successful flight is the first step in establishing a safe, cheap, and reliable method of reaching low Earth orbit. He predicted that SSI would be able to offer launch vehicles for commercial payloads to such orbits by September 1984. Space Services hopes to be able to put a commercial payload into orbit for about $5 million. NASA would charge about $35 million for a similar job.

Hannah added that representatives of his firm have talked with several other companies that are interested in the possibility of putting satellites into low Earth orbit. Oil and gas companies interested in doing exploration work are those mentioned most often by SSI officials.

"The possibilities of low Earth orbit are relatively unexplored at this point. There's a lot of things that could be done from that orbit, but nobody's ever looked at it," said Donald K. "Deke" Slayton, a former NASA astronaut who is now vice-chairman of SSI. Slayton's addition to the SSI team is one of many important changes the company has made in its operations within the last year.

SSI's first attempt at a suborbital flight ended in disaster on August 5, 1981, when a liquid-fuel rocket exploded on its launch pad during an engine test. The SSI crew for that attempt was largely made up of graduate engineering students.

Conestoga I was launched with the help of several professional firms experienced in rocket launching and tracking. They included Eagle Engineering Co. of Houston, Space Vector Corp. of Northridge, California, and the West German firm DFVLR. Space Vector has launched more than 20 rockets for NASA and the military, and DFVLR specializes in missile tracking and telemetry.

SSI officials estimate that they have spent approximately $6 million from more than 50 investors in their attempt to bring private enterprise to space. That figure includes $1.2 million for the unsuccessful first attempt and $2.5 million for the successful second launch.

Galileo Jupiter Probe Test

On July 17th, NASA scientists conducted a successful test of a Galileo Jupiter-atmosphere probe spacecraft over White Sands Missile Test Range.

The balloon-borne experiment originally had been scheduled for early June, but unfavorable weather, technical problems, and range scheduling delayed the operation.

After an early morning balloon launch from Roswell, New Mexico (lifted by 5.14 million cubic feet of helium), the probe made a four-hour flight before being dropped from 97,000 feet. The Galileo "deceleration module" consisted of a heat shield (with a form-fitting aluminum and lead-shot ballast package added), aeroshell, parachutes, and instrumentation.

At 50,000 feet, the probe's speed had reached Mach 1 and the dynamic pressures on it were quite similar to what they would be during the parachute opening at Jupiter. After its pilot chute deployed and the main parachute opened, the probe's aft heat shield, extra ballast, and *the aeroshell structure were all* scheduled to detach automatically. The probe landed about eight miles south of the White Sands

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Camera-equipped telescopes and radar recorded both the Galileo probe's separation from its carrier balloon and the parachute deployment sequence.

Shortly after the test, Galileo project manager Joel Sperans (of NASA's Ames Research Center, in Mountain View, California) reported that a quick look at the on-board camera data indicated that the probe's entire descent sequence had worked properly, except for a one-second delay in the parachute's opening and the failure of some ballast to separate properly. He said that the test was a major milestone in the development of the Galileo atmosphere probe spacecraft, which will be sampling Jupiter's atmosphere sometime between 1987 and 1989.

Over the next several weeks, detailed analyses of all the data, including the ground-based electronic and optical information, showed that the main parachute actually took 4.5 seconds too long to open. This caused a slower deceleration than planned, resulting in the ballast failing to separate from the heat shield.

However, according to project scientist John Givens, this failure and the late opening of the main chute would pose no problem during an actual descent into Jupiter's atmosphere. He noted that hundreds of tests with similar parachutes show that they will eventually open under these conditions. Furthermore, since there will be no ballast on the actual mission for the heat shield to decelerate away from, no problem would result. Nevertheless, the 4.5-second delay was enough to worry a number of Sperans's and Givens's colleagues; they scheduled a conference in late August to study the problem and possible solutions.

However, all indications are still that the Galileo probe's subsystems will be integrated and tested in 1983, and be ready for launch by a Space Shuttle / Inertial Upper Stage (IUS) in 1985, or a Centaur launch in 1986.

The Galileo probe should then reach Jupiter in 1987-88 (if by Centaur) or 1989 (by IUS). In any event, the probe will be released one hundred and fifty days before encounter with the planet, in order to intercept the atmosphere at an 8° angle, with a speed relative to Jupiter of 48 kilometers per second.

The 340-kilogram probe will become a meteor as it streaks through the outer edge of the planet's atmosphere. Atmospheric friction will generate heat at a rate of about 40 kilowatts per square centimeter. The probe's thermal blanket, part of its protection from the extreme cold of space, will rapidly burn off. Several megawatts of light, heat, and other radiation will be produced by the heat shield during the short entry phase.

Essentially, the probe will go through the equivalent of a nuclear explosion. Its ablative heat shield, a four-inch-thick carbon-cloth / phenolic laminate, will generate a shock layer with a temperature of over 15,000° Celsius. In turn, the shield will be heated to between 4000° and 5000° C, the temperature of a sunspot. In fact, it will become hot enough to generate X-rays.

When the probe reaches an altitude of about 450 km above Jupiter's "surface" and has slowed down to Mach 1, a mortar will fire to blow away the aft heat shield. Shortly afterward, the forward cover and aeroshell will come off and the large parachute will deploy.

The probe will then begin its hour-long descent to a depth having at least 20 atmospheres of pressure, all the while measuring and transmitting data on cloud levels, the type and density of gases present, the ratio of hydrogen to helium, lightning strikes, and the difference between incoming solar energy and the amount of radiation leaving the planet. Project scientists and engineers hope that the mission might extend for another 15 minutes — until the probe reaches a depth with a pressure of about 25 atmospheres — before increasing pressure and temperature silence the probe. *Steve Greenberg.*

New Models for Galactic Evolution

Under what general conditions can one star induce the formation of another star? No one knows for sure, but a Case Western Reserve University astronomer is experimenting with various mathematical models based on induced star formation in an attempt to develop a theory of how galaxies evolve.

Steven Shore is basing his studies on the work of numerous other astronomers who have theorized about induced star formation and its role in the life of a galaxy. This type of research has become necessary since recent findings have uncovered flaws in the density wave theory, which was once used to explain the spiral structure of galaxies.

Astronomers are now working on the development of numerical models that suggest possible evolutionary histories of spiral galaxies. Shore says he's trying to unify the existing models into something more general. "Ideally, I would like to put my finger on the critical supernova rate within a region of a galaxy below which you get no induced star formation, and above which you get nearly complete star formation," Shore explains.

As part of his studies, Shore wonders why there are periodic episodes of star formation in galaxies rather than a relatively constant stellar birth rate. "We've known for a long time that galaxies can go through bursts of activity," Shore notes. "We've seen some galaxies which have excessive numbers of blue stars, which indicates the stars were young — formed within the last 10 million years."

An interesting sidelight on this work has developed in the efforts of Lawrence Schulman and Phillip Seiden at IBM's Watson Research Center in Yorktown Heights, NY. They were experimenting with the popular "Life" game — which scientists can play on computers — when a co-worker pointed out that the circular grid they were working on resembled a spiral galaxy. They had, in essence, built a galaxy by rolling dice.

Among the factors to be considered in developing a theory of galactic evolution is the randomness of star formation — much like the randomness that occurred in Schulman's and Seiden's grid. That is, star movement throughout a galaxy is random, and therefore, any individual star's influence is likewise random.

"Galaxies rotate so that regions which are initially close together can be sheared apart. If that shearing happens fast enough, then a star that is affecting an area can live long enough until it is well away from its initial site of interaction and starts affecting a new part of the galaxy," Shore maintains.

To help him understand star movement, Shore looks at the transmission of diseases through a human population. He finds this helpful because humans, like stars, move randomly through populated and unpopulated areas.

"If you have a disease that must be transmitted by contact — measles is a good example — then you have healthy people who can be infected," Shore explains. "Two things can happen to those who get the disease: They can recover or they can die. During this time, they have a period when they can infect someone else. The same thing happens with stars. Stars are born, move around and may induce clouds of gas and dust to collapse into more stars."

The collapse can be caused by a supernova explosion, Shore notes. The shock wave of the explosion pushes on a nearby interstellar cloud, forcing the cloud to contract. If the push is hard enough, the cloud will pass a stability limit and begin collapsing on itself.

But there are other natural phenomena to consider, Shore says. "The second possibility is that a star can die quietly like a

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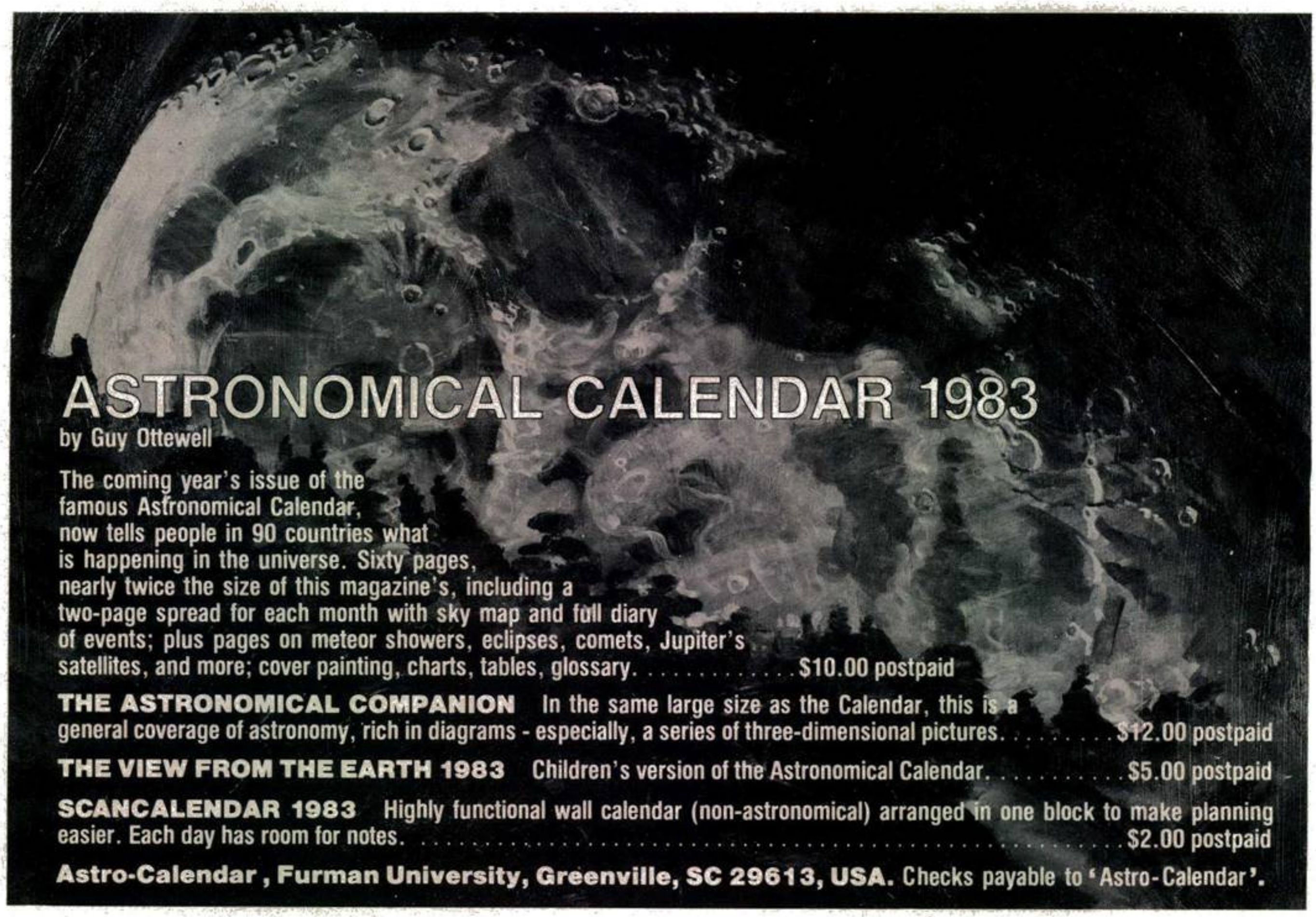

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by Guy Ottewell

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ASTRO NEWS

planetary nebula, without inducing a new star to form. A third possibility is that a star could form spontaneously, just because of the natural instability of the cloud."

Star formation wasn't always looked at this way. Astronomers considered star formation as a natural and incidental process, rather than a specifically caused event, because they had the density wave theory which seemed adequate at the time. "In the late 1960s and early 1970s, it became more and more obvious from theoretical studies that these processes just didn't work," Shore says. "The processes didn't last long enough. Astronomers had to keep rethinking them.

"That's when the idea of sequential star formation began to take hold, and, from the observational and the theoretical side, it provides a much better understanding of the way a galaxy evolves, " he adds.

Shore says the numerical simulation he performed shows that periodic bursts of star formation do, in fact, result when certain thresholds are crossed. This, he points out, failed to appear in earlier mathematical models.

The research also includes comparing thousands of galactic photographs, which can indicate the chemical composition of galaxies. Through the photographs, an astronomer can determine the relative age of a galaxy as well as when its periods of more active star formation happened. By grouping galaxies in apparent age ranges, a picture of galactic evolution emerges: age is determined by measuring the amount of "metals," elements which are heavier than helium. The more metals a galaxy contains, the older it is.

Shore comments, "What these models have produced, for the first time, is a theoretical prediction for a rate of star formation, rather than simply a broad assumption. That's a start; our next step is to include the random processes which we know must be occurring. It won't be a final answer by any means, but the picture ought to be a lot clearer." *Dennis Sadowski.*

Lightweight Shuttle Tank

The Space Shuttle's first Lightweight External Tank (LWT-1) was rolled out of the manufacturing plant at NASA Michoud Assembly Facility in New Orleans on September 10.

At about 66,000 pounds, LWT-1 is about 10,000 pounds lighter than the External Tank used for the Space Shuttle's maiden flight in April 1981. The tank's reduced weight will provide the Shuttle with extra payload-carrying capability of almost one pound for every pound of tank weight shed.

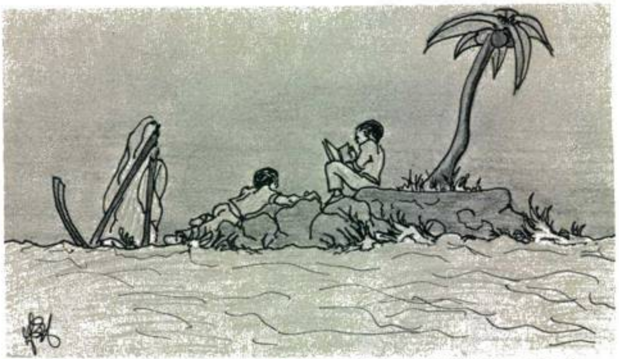
The large brown External Tank carries the super-cold liquid oxygen and hydrogen propellants for the Space Shuttle's main engines and acts as the structural "backbone" of the Shuttle vehicle. The tank's three major components are an oxygen tank, a hydrogen tank, and a collar-like intertank that connects the two propellant tanks and houses the entire structure's instrumentation.

According to James Odom, manager of the External Tank Project Office at the Marshall Space Flight Center, the weight reduction was accomplished by eliminating portions of stringers (structural stiffeners running the length of the hydrogen tank), using fewer stiffener rings, and by modifying major frames in the hydrogen tank. Also, large portions of the tank were milled differently to reduce thickness and weight, and the weight of the tank's aft Solid Rocket Booster attachments was reduced by using a stronger, yet lighter and less expensive titanium alloy.

"Several hundred pounds were also eliminated by deleting an anti-geyser line," said Odom. This line acted as a built-in refrigeration system, keeping oxygen at its super-cold temperature while filling the oxygen tank prior to launch. NASA officials decided to remove the line after assessing propellant loading data from ground tests and the first few shuttle missions.

Although most of the tank's alterations will not be apparent to the casual observer, one change is already obvious — six hundred pounds of white latex paint was eliminated from the tank's surface before the third Shuttle flight. After analyzing data from the first Shuttle mission, NASA officials determined that the External Tank's thermal protection system would adequately protect the tank without the paint.

After rollout, the tank was loaded aboard a NASA barge for shipment to the Kennedy Space Center in Florida where it will be prepared for flight. The new lighter-weight tank will be flown on the sixth Space Shuttle mission, now scheduled for January 1983.



Boy What Luck! Dec. 21, 1988, we'll be right in the path of a solar eclipse!

Cartoon by Gary Hertzler

ASTRO CALENDAR

November 15-18.	**Chondrules and their Origins** (professional meeting). Lunar and Planetary Institute, Houston, Texas. Contact: Pamela Jones, Lunar and Planetary Institute, 3303 NASA Road 1, Houston, Texas 77058 or Albert King, Department of Geosciences, University of Houston, Houston, TX 77004.
January 9-12, 1983.	**The 161st Meeting of the American Astronomical Society** (professional meeting). Joint meeting of the Solar, High Energy Astrophysics, and Historical Astronomy Divisions. Contact: AAS, 1816 Jefferson Pl., N.W., Washington, D.C. 20036.
April 15-18.	**National Congress of Astronomers,** Astronomical Society of Southern Africa. Contact: M. Andrew Gray, P.O. Box 118, Johannesburg 2000, Republic of South Africa. Phone 011-394941 (Office) or 011-469391 (home).
June 13-19.	**Joint Meeting of the Astronomical Society of the Pacific and the Western Amateur Astronomers,** on the Kona coast of the Big Island of Hawaii. Contact: Hawaii Meeting, A.S.P., 1290 - 24th Avenue, San Francisco, CA 94122.

Meeting notices to appear in AstroCalendar must be submitted at least three months in advance of the meeting date. Most organizations appreciate your enclosing a long (business-size) self-addressed, stamped envelope along with your request for information.

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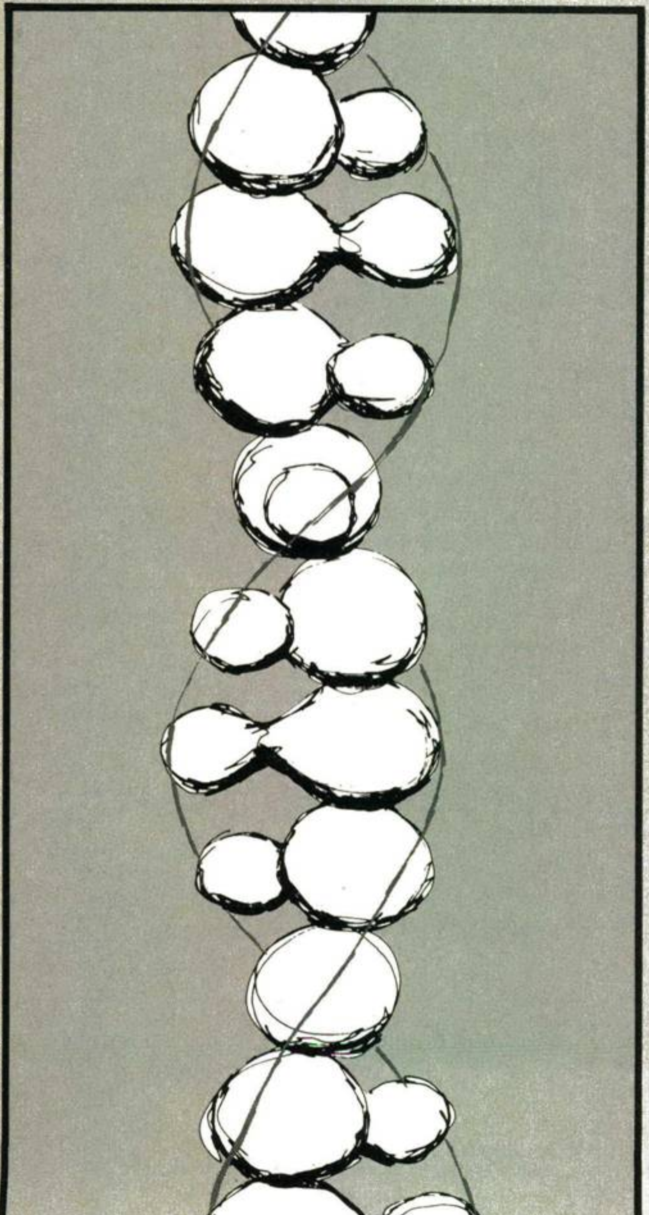
CONTACT BINARIES

Stars That Touch

by
Ken Croswell



Consider this simple question: Are stars alone in space? A quick examination of our solar system, for example, suggests that stars traverse the Galaxy as solitary beacons, attended, perhaps, by a few planets. But, in fact, most suns have stellar partners. Our lonely star is the exception, one of the minority.

Many of the best-known stars in the sky — Sirius, Procyon, Antares — are really double, with very faint companions orbiting the bright primary stars. Perhaps even more surprising: many binaries are not stately systems, the component stars separated by billions of kilometers, like Albireo or Algol. Instead, many co-orbiting stars appear to be in physical contact, touching, either sharing a common envelope of gas or somehow stuck together. These bizarre systems are known as contact binaries.

What is a contact binary? No astronomer has ever seen stars in contact as such. Since the two components are so very close, they invariably appear as a single object through even the largest telescopes. Astronomers identify them by measuring the minute blueshifts and redshifts in the system's spectrum produced as the stars alternately approach and recede from us. In addition, contact binaries are variable stars. Those systems whose orbital planes lie close to the line of sight of an observer on Earth undergo periodic eclipse. The change in brightness may be anywhere from a few tenths of a magnitude to a little more than one magnitude. Variations in light output also occur out of eclipse, however, and this suggests an exchange of material between two extremely close components. But just how do stars "touch" one another?

When a binary star is extremely close to its partner, it interacts through its Roche lobe, or realm of gravitational influence. Massive stars have larger Roche lobes than small stars. If a particle, say an asteroid or a bit of gas, is placed inside a star's Roche lobe, the star will normally be able to hold on to it. If the particle is outside the Roche lobe, it can escape the star. The normally spherical surfaces of two stars in close proximity are distorted into teardrop-shaped configurations touching at their tips. The Roche surfaces of all paired stars touch — but the stars themselves are usually much smaller than their Roche lobes.

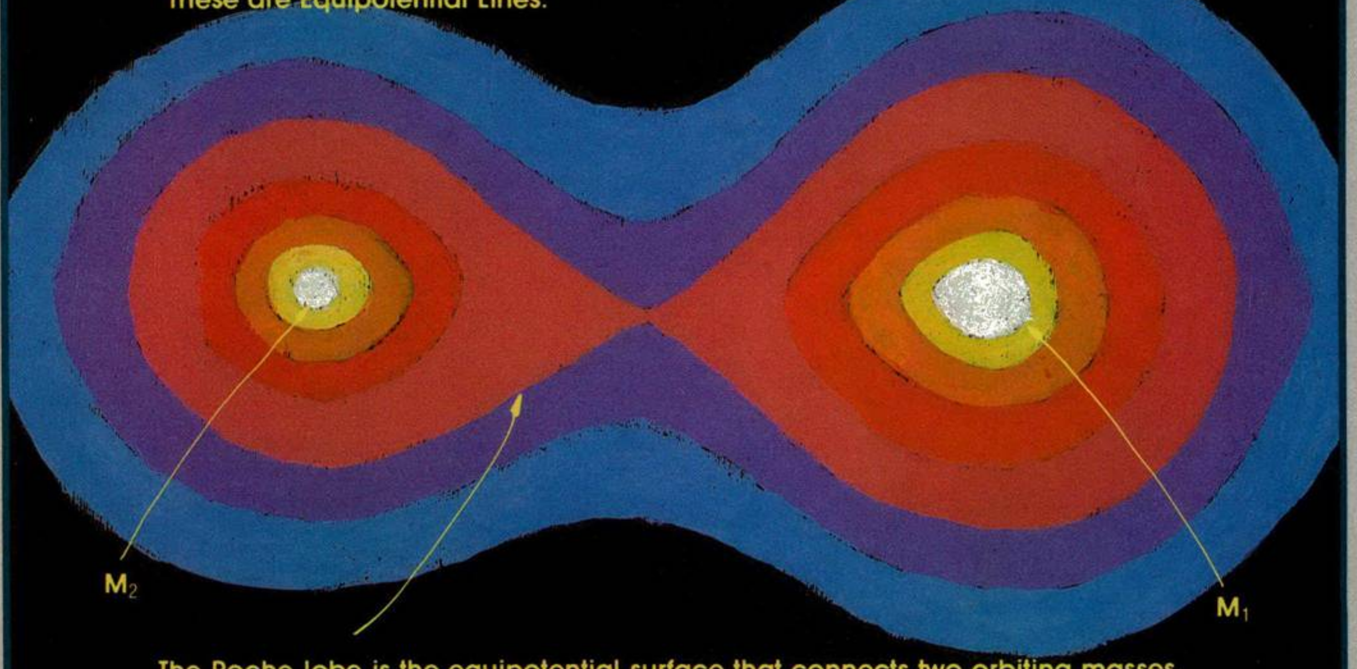
In 1955 astronomer Zdenek Kopal first classified all close binaries into three groups — detached, semi-detached, and contact systems. In a detached system, both stars remain well within their respective Roche lobes. In a semi-detached system, however, one component fills its Roche lobe. The place where the Roche lobes of both stars meet represents a middle ground between the gravitation of each component. Here a particle will not know which way to fall and a star that fills its Roche lobe will lose material to its companion. Semi-detached binaries, like the "demon star" Algol, can thus slowly exchange matter. (See "The Wink in the Demon's Eye," ASTRONOMY, December 1980.) Contact binaries are still more exotic — both components fill their Roche lobes and continually interact.

Astronomers distinguish two classes of contact binaries, type A and type W. In A-type systems, the deepest eclipse occurs when the less massive star transits, or passes in front of, the more massive one. In these systems, the more massive star is the bigger and brighter of the two. In W-type systems, named after the prototype contact binary W Ursae Majoris, the deepest eclipse happens when the more massive and larger star blocks the smaller, less massive, but brighter star. The frequency of the eclipses indicates the orbital periods of the components — from as little as six hours to as long as one day for both binary types, with most W-type systems residing in the six to twelve-hour range.

In 1948, Harvard astronomer Harlow Shapley found that W UMa stars are 10 to 30 times more common than all other eclipsing variables combined. Overall, roughly one out of every 1000 to 2000 pairs of stars that have the same

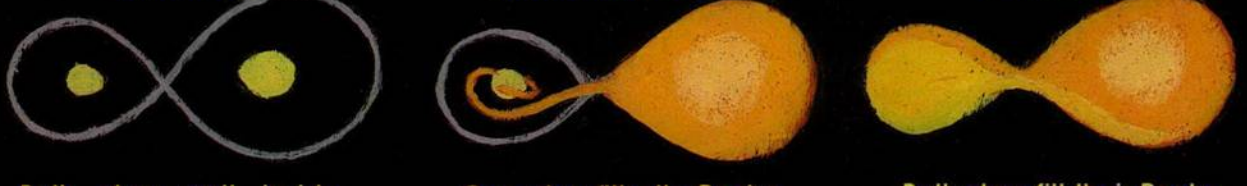
A GRAVITATIONAL VIEW OF A CLOSE BINARY

Along any one contour, a particle feels the same combined force from both stars. These are Equipotential Lines.



The Roche lobe is the equipotential surface that connects two orbiting masses. Should either star fill its Roche lobe, its material will flow through the bottleneck to the other star.

BINARY CLASSES



Detached

Both stars well inside Roche lobes.

EXAMPLE: β Aurigae

Semi-detached

One star fills its Roche lobe.

EXAMPLE: Algol (β Persei)

Contact

Both stars fill their Roche lobes.

EXAMPLE: 44 Bootis B

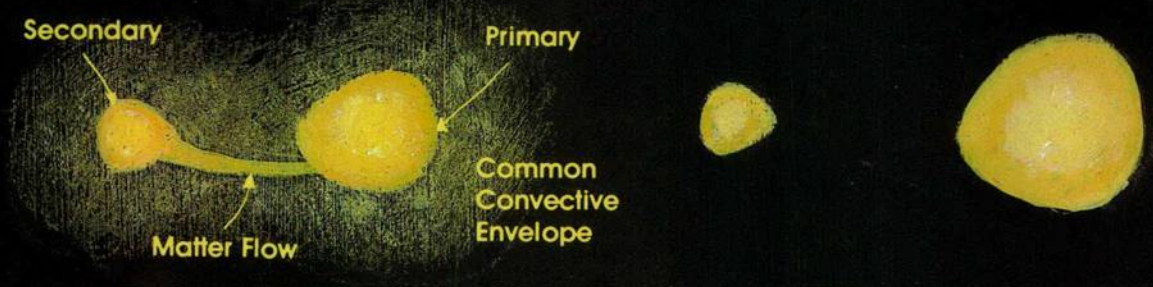
spectral type are W UMa stars. As Kopal wrote in 1978, "There seems no escape from the conclusion that the W UMa-type stars represent the commonest type of [close] binary systems in space around us." Since these systems are so abundant, let's take a more detailed look at their composition.

W-type binaries have modest, solar-like masses and luminosities. Total system masses range from about 0.8 to around 3 solar masses, and absolute magnitudes range from roughly +4 to +6. A-type systems, on the other hand, are somewhat brighter and more massive than type W binaries, with absolute magnitudes up to around +2 and total masses that can reach 4 or 5 suns. Spectral types for type W contact binaries are usually late F or G, similar to that of the Sun. In contrast, A-type systems have earlier spectra, usually spectral class A (the source of their name) or occasionally B.

Binaries are useful systems for astronomers because two stars in orbit obey well understood laws of motion. From their orbital velocities and periods, it's possible to calculate the combined and individual masses of the stars in a system. Detached binaries come in all combinations and variations of mass — but with one possible exception, astronomers have never found a contact binary in which the two stars are of equal mass. Their average mass ratio is 2:1, and several extreme pairings occur: Epsilon Coronae Australis has a mass ratio of 11:1, and AW Ursae Majoris has a mass ratio of 12:1. On the average, A-type binaries have more extreme mass ratios than W-type systems. In many cases, the primary — the more massive of the stellar pair — is fainter than a star of its spectral type would normally be, or "underluminous" in the astronomical jargon, while the secondary is a bit brighter than normal.

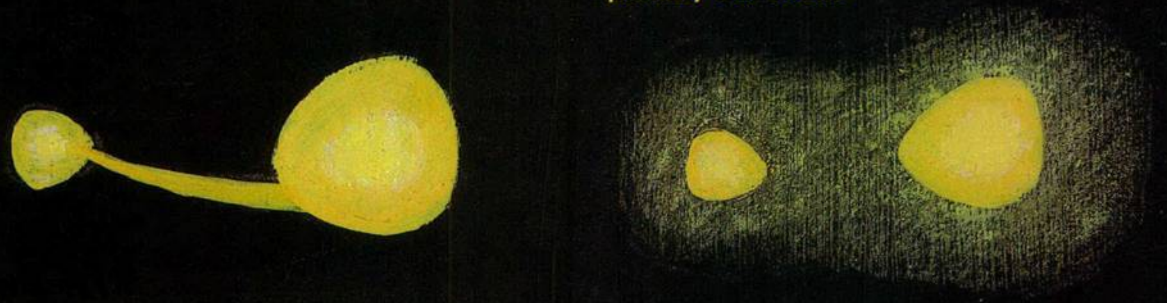
When stars are plotted by their brightness and spectral type on a Hertzsprung-Russell diagram, most stars fall onto a narrow band called the main sequence. But the stars that compose close binary systems are not the same luminosity as stars of similar spectral type, so they fall slightly off the main sequence — the primary star tends to lie below it, the secondary above it. Why should the components of contact systems behave differently than other stars? Is there

TRO THEORY FOR TYPE W BINARY



Mass flows from secondary to primary

To conserve angular momentum, the stars move apart. Contact breaks because no common envelope surrounds the system. The secondary star contracts and the primary star swells.



The primary now loses mass to the secondary. To conserve angular momentum, the stars move closer together.

Contact is re-established through a common envelope. The secondary now swells and the primary contracts. The system is ready to repeat the cycle.

something about being in a close binary system that makes the components abnormal?

Once formed, a star usually spends most of its life on the main sequence. Later, when internal changes cause it to bloat and redden, the star rapidly moves off the main sequence and into the realm of the red giants. The star will eventually exhaust its fuel and, depending on its mass, either explode as a supernova or collapse to spend its final days as a tiny white dwarf. In the early 1960s, Olin J. Eggen discovered a strange relation between the spectral types and orbital periods of contact systems — one indication that stellar evolution progresses normally in contact systems. Eggen found that the cooler (redder) a system's spectral type, the shorter its period.

Unfortunately, the modest brightness of contact systems makes them difficult to observe. While more than four hundred such stars are known, only a few dozen have been studied in detail. Other variable stars, like the Miras or Cepheids, are well known because they are composed of highly luminous giant or supergiant stars. But only a few dozen contact binaries are brighter than apparent magnitude +10, in spite of their abundance. The only system possibly visible to the unaided eye is 44 Bootis B, which reaches magnitude +6.0 at maximum light.

The paucity of observational data has hampered attempts to understand contact systems, but in 1941 Gerard Kuiper argued that two stars could form in contact and remain in dynamically stable orbits. While this seems to be significant progress, Kuiper's model only worked if the component stars were of the same mass. But the observed components of contact binary systems almost always differ in mass, sometimes by a large degree. This discrepancy became known as Kuiper's Paradox.

There are two ways to avoid introducing the paradox if the stars really are physically stuck together. We can assume either that the binary did not originally form in contact or that the components are *not in stable orbits*. In 1968, Leon B. Lucy of Columbia University used these assumptions in an attempt to model both classes of contact binaries. But before examining his ideas, we must first discuss the methods by which normal stars distribute their thermal energy.

The two most important processes by which the transfer of heat can occur in stars are radiation and convection. Radiation is the communication of heat by photons. Convection is the transfer of heat by large movements of mass — like the convective uplifts that build cumulus clouds on warm summer days. Astronomers have determined from theoretical calculations that the core of a star hotter than spectral class F5 transfers heat through convection, while its surrounding envelope uses radiative transfer. Cooler than F5, however, the situation is reversed — the core uses radiative transfer, the envelope convective transfer.

Lucy proposed a slightly different model for each binary class. A-type systems, he suggested, are in stable orbits, but were *not* contact systems when they were created. Perhaps A-type systems formed as detached or semi-detached binaries and later evolved into contact. However the stars formed, the assumption that they had not originated in contact resolved Kuiper's Paradox for this case.

For type W systems, the model was more complicated. Since W-type systems are the most abundant type of close binary, it is impossible for them to be a transient state in the life of some other binary class — there just aren't enough other types of close binary for them to become.

Not only were W-type stars in stable orbits, Lucy argued, but they had originally formed in contact and were dynamically unevolved systems. But doesn't this invite Kuiper's Paradox? The problem hinges on how the term "contact" is defined. Kuiper's work holds true only if the stars are assumed to be stuck together, but Lucy showed that this argument no longer applied if the two stars were surrounded by a common convective envelope that emitted the combined energy of the two stars. Thus the W-type systems can exist as contact binaries from their creation and remain in equilibrium.

It was an elegant idea, but did it fit the observations? Lucy's model succeeded in reproducing the observed light curves and also gave the correct average total mass of W-type systems (although the predicted range in total masses was narrower than actually observed). But there was absolutely no agreement with the strange period-color relation observed by Eggen.

Lucy's work stimulated the development of many other contact binary models. Nearly all the theories incorporated his idea of a common convective envelope, but none worked perfectly. As more and more versions of his original idea were tested by various theorists, it became obvious to Lucy that the common convective envelope idea simply would not work, and he finally conceded defeat. In 1976 he wrote, "Variations of the model's parameters within acceptable limits fail to yield even rough agreement with Eggen's period-color relation, which is perhaps the best test of theories of the structure and evolution of these binaries."

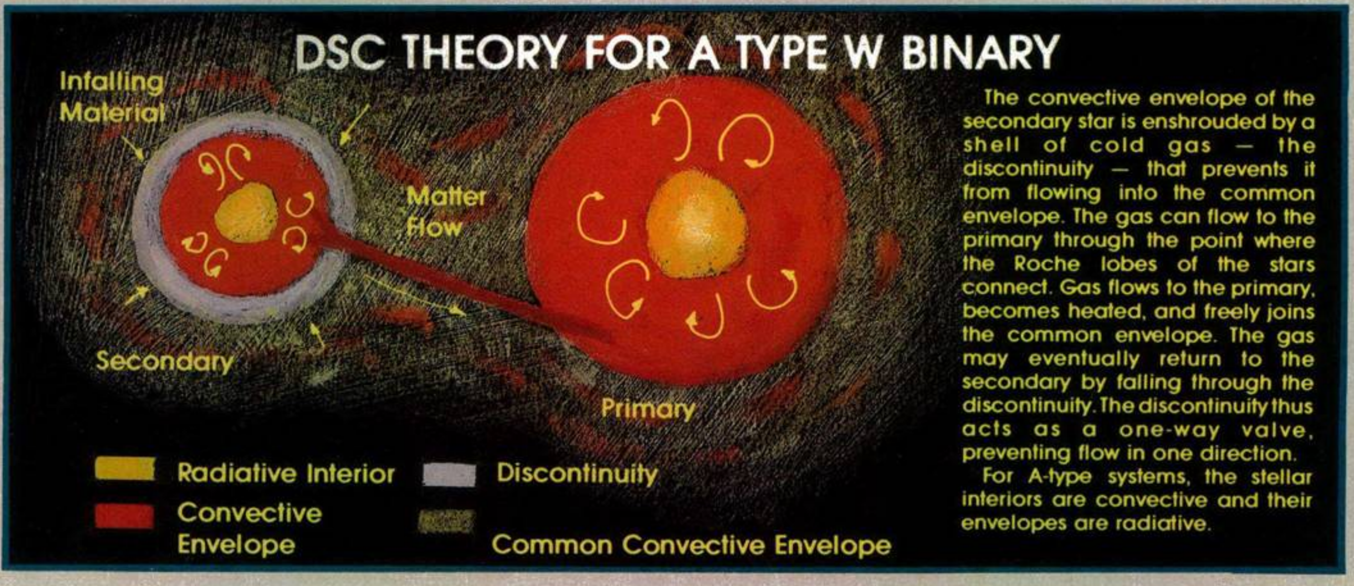
Lucy (and independently Brian P. Flannery) then went on to propose a new and revolutionary model, one of the two main theories now in vogue. It still calls for W-type systems to be unevolved, but the stars are no longer thought to be in unchanging orbits. Instead, the two components oscillate between a state of marginal contact and one of no contact, with a typical period of oscillation being around 10 million years. The new model is called thermal relaxation oscillation, or TRO.

To see how it works, consider a typical system with the primary in contact with the secondary. Every star of a given mass and chemical composition will naturally assume a certain size if no external forces are present. If, say, the primary is its natural size, then, according to Lucy, the secondary must be compressed since it is in contact with its partner. Since the secondary is compressed, its rate of nuclear reactions increases and it produces more energy in its interior, causing it to expand slowly. This expansion causes the secondary to lose some of its mass to its companion, and the extra mass compresses the primary. The mass ratio becomes progressively more extreme and, in order to conserve angular momentum, the two stars slowly separate. Contact is broken by the separation because the stars are too far apart to share a common gaseous envelope.

The primary expands once the pressure of mass transfer is off and the star's mass gain causes it to heat up; the secondary now contracts because of its decreased mass. But as the primary expands beyond its Roche lobe, it begins to dump mass onto the now-shrunken secondary, which now becomes compressed. The mass ratio becomes less extreme. The stars move together again in order to conserve angular momentum. As the distance between the components decreases, a common convective envelope enshrouds the stars — they are again in contact. Then the cycle begins again.

Lucy suggested that type A systems were in full contact and in equilibrium. He also argued that the A systems had evolved into the contact condition from some other binary class, and suggested that type W systems may evolve into A-type binaries.

There is, however, another theory. Frank H. Shu, Stephen H. Lubow, and Lawrence Anderson developed the


DSC THEORY FOR A TYPE W BINARY

The convective envelope of the secondary star is enshrouded by a shell of cold gas — the discontinuity — that prevents it from flowing into the common envelope. The gas can flow to the primary through the point where the Roche lobes of the stars connect. Gas flows to the primary, becomes heated, and freely joins the common envelope. The gas may eventually return to the secondary by falling through the discontinuity. The discontinuity thus acts as a one-way valve, preventing flow in one direction.

For A-type systems, the stellar interiors are convective and their envelopes are radiative.

contact discontinuity (DSC) model for both W and A-type binaries. Here the stars are considered to have originally formed as contact systems; they are also in equilibrium. This situation can only avoid introducing Kuiper's Paradox by assuming the existence of some sort of barrier between the stars — a "contact discontinuity."

To see how DSC theory works, let's examine the case of a W-type binary. The system consists of two radiative interiors, each surrounded by its own convective envelope. These two envelopes are themselves surrounded by a gaseous envelope that enshrouds both suns. The contact discontinuity is a layer of cool gas surrounding one of the stars; it shields the star's convective envelope and keeps stellar material from flowing into the hotter gas in the common envelope. Normally, convective currents in the stellar envelope would mix the cool gas into the hotter common envelope, but the contact discontinuity prevents this from happening. Instead, the cool material from the star's convective envelope flows directly to its partner, where it is heated and mixed with the material of the receiving star.

Since the receiving star does not have a contact discontinuity, its material can flow into the common convective envelope that surrounds the stellar pair. Once in the common envelope, the gas cools and eventually penetrates the contact discontinuity to join the atmosphere of the donor star. The donor's gain of material from the common envelope exactly compensates its loss of material through the gravitational "middle-ground" between stars. Thus the contact discontinuity acts as a one-way screen, allowing flow from a common envelope to the donor but prohibiting flow in the opposite direction. A similar scheme holds for A-type binaries, except the cores are now convective and the envelopes radiative.

TRO and DSC are today the only theories that come close to explaining contact systems completely, but both have been accused of theoretical shortcomings. For example, some scientists remain unconvinced that the oscillation proposed in TRO theory would really be set up, and others claim that the contact discontinuity of DSC theory is unstable and would break down quickly. The real battleground for the two theories, however, must be the observational arena. Both TRO and DSC models do a fairly good job in reproducing Eggen's period-color relation and the observed light curves, and both give correct mass ratios and total masses.

In 1978, R.E. Wilson surveyed eight A-type contact binaries. He found that all eight systems had larger radii than would be expected if they were originally created in contact. This suggested that A-type systems evolved into contact and supported TRO theory.

But Lucy admitted to one significant shortcoming of the TRO model — no known systems of broken contact exist. If W-type contact binaries oscillate between states of marginal contact and no contact, then surely some systems ought to be found in broken contact — and there appeared to be none. In 1979, however, Wilson and he reported the discovery of three such unconnected binaries — AK Herculis, W Corvi, and RW Piscis Australis — and called them B-type (broken) systems.

In 1981, Stefan W. Mochnacki of the California Institute of Technology disputed this claim. Mochnacki identified what seems to be a third subclass of contact binary. In addition to types W and A, he claimed that another subclass existed, which he called OO Aquilae stars after their prototype system. He suggested that these stars have evolved into contact from a detached configuration; his examples include W Corvi and RW Piscis Australis — two of the systems claimed to be broken by Lucy and Wilson. Furthermore, Mochnacki claimed that the third supposedly broken system, AK Herculis, is really an A-type system that has evolved from a type W. If this is correct, then no broken W-type contact binaries have yet been discovered — even though TRO theory predicts that some should exist.

Touching Suns: A Prototype

W Ursae Majoris is the prototype of class W contact binaries, often simply called W Ursae Majoris stars. Type W systems are the most common variety of contact binaries.

W Ursae Majoris itself lies about 200 light-years away and varies in apparent magnitude from +7.9 to +8.7 in a period of 8 hours 27 seconds. Brightness may vary even far from minima and maxima, indicating that the two stars are very close together. The primary is of spectral type F8, absolute magnitude +4.42, with a diameter 1.14 times greater than the Sun's. Its mass is equal to that of the Sun, and its luminosity is 1.45 times that of the Sun. The secondary's spectral type is F6 and its absolute magnitude is +4.75. Although its diameter is 0.83 that of the Sun and its mass only about 60% that of our star, the secondary shines with Sol's luminosity.

The distance from the center of one star to the center of the other is estimated to be less than a million miles, or about 1/100 the Earth-Sun distance, and both stars are distorted into ellipsoids by mutual gravitational pull. The contact binary forms a common motion pair with BD +55°1351, about 435 astronomical units from it.

One of the major questions concerning contact binaries is their evolution, which is interesting both for its own sake and because it bears on the TRO/DSC controversy. What kind of future can a typical contact binary look forward to? Not surprisingly, there are two main theories, and they break pretty much along party lines.

In 1976 Ronald F. Webbink of the University of Illinois used TRO theory to argue that the component stars of a contact system must eventually coalesce into one. When the primary bloats into a red giant near the end of its life, its radius will increase far enough to engulf the secondary, and the two stars will merge. Proponents of the DSC theory accused Webbink of using "dubious concepts" (i.e., TRO theory) and suggested instead that contact binaries eventually evolve into cataclysmic binaries like U Geminorum. Cataclysmic binaries consist of a large red star and a white dwarf, which occasionally captures some of its partner's material. As this material falls onto the white dwarf, a sudden increase in luminosity is observed. Cataclysmic binaries and contact binaries share similar total masses, space distributions, and short periods — strongly suggesting the possibility that contact binaries evolve into cataclysmic systems. As it happens, DSC theory calls for such evolution.

However dubious Webbink's suggestion of coalescence is, he may very well be right. He predicted that after coalescence the star would be a giant of type G with an equatorial rotation speed of 100 km/sec and a period of a few days. In 1981, Bernard W. Bopp of the University of Toledo and Robert E. Stencel of the University of Colorado discovered three stars with just such characteristics: FK Comae Berenicis, UZ Librae, and HD 199178. (See "Have Two FK Comae Giants Coalesced into One Star?" AstroNews, ASTRONOMY, January 1982.) This discovery lends strong support not only to Webbink's proposals but also to TRO theory in general.

Still, no one dares claim a complete understanding of suns that touch. Indeed, the 1981 study by Mochnacki concluded that neither TRO nor DSC fully explain these mysterious objects. The theorists will certainly continue to argue and undoubtedly propose still more theories about these exotic objects that are, in spite of their strange appearance, incredibly common in the universe as a whole.

Ken Croswell is majoring in physics at Washington University in St. Louis and plans to do graduate work in astrophysics. He has been a frequent contributor to AstroNews.

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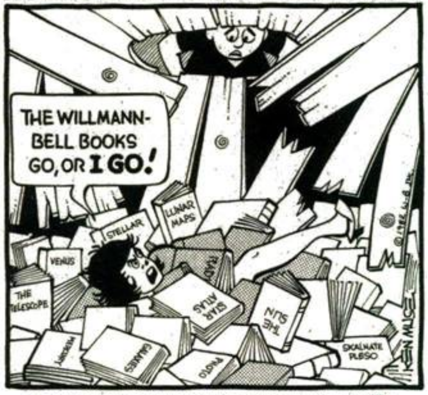

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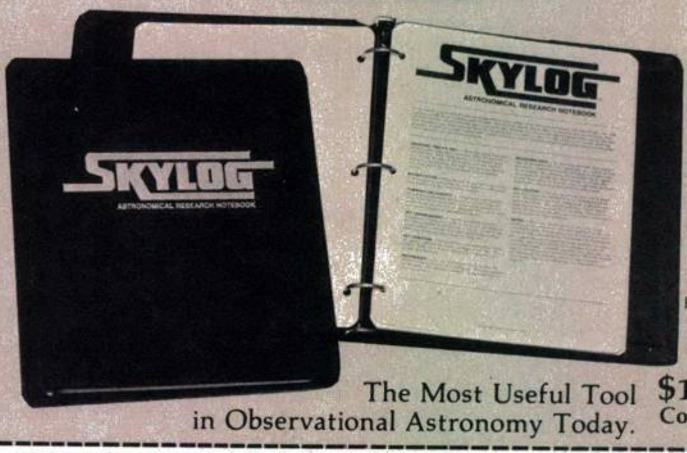

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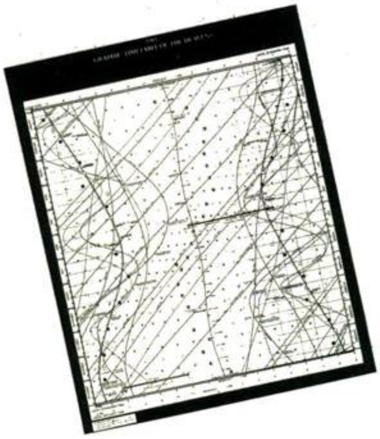

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the telescope revolution

equipment atlas

It was a peaceful scene. On a quiet hillside in Vermont, hundreds of attentive people listened to a man speaking. Imagine that you're there. In the gathering dusk, you can see dozens of home-built telescopes, and in the sky a few stars have begun to shine.

"We're in the middle of a violent revolution," says the speaker, "a revolution in telescope making.

"I came up here today and what did I see? One word says it all: Dobsonians. One old-timer just kept walking around today and saying, 'I don't believe it, I don't believe it.' "

The scene was this year's Stellafane. The speaker was Walter Scott Houston — a man who's been using telescopes for some fifty years. He spoke of a movement that began in Springfield, Vermont over 50 years ago, a telescope building movement that spread across the country, begun by people who didn't know how radical they were.

"People changing a culture — or part of it — don't know what they're doing. Well, they *were* engaged in a revolution, in bringing telescopes within the reach of people like you and me."

But the revolution ran out of gas. "In 1930," he said, "I had a 10-inch, and in the late 1960s, I still had a 10-inch. Those forty years were a period of stagnation."

But another revolution began in the seventies. Amateur telescope making — and with it, amateur astronomy — changed. We have all noticed the fruits of the revolution. A 10-inch telescope is now the *smallest* in one manufacturer's product line — a line that includes 13-inch, 17.5-inch, and 29-inch aperture telescopes. And other manufacturers have responded by adding telescopes larger than 12 inches to their product lines and keeping prices low.

"I picked the right year to say it," mused "Scotty" Houston the next day; "just look at the telescopes on Breezy Hill this year. Half of them are Dobsonians." Even the most casual glance reveals that telescope builders are doing things today that simply weren't being done ten years ago.

Commercial telescopes, you see, are just the tip of the telescope-making iceberg. The real action still lies with home-built telescopes. Whenever amateur astronomers get together, big telescopes abound — telescopes with apertures almost unimagined by hobbyists ten years ago. On display at this year's Riverside Telescope Maker's Conference, for instance, were four or five 16-inch reflectors, six or seven 17.5-inchers, an 18, two 20s, a 22-incher, and a 24-incher.

The Dobsonian Revolution

Dobsonians — those big, squatty alt-azimuth mounted Newtonians — exploded into prominence since amateur telescope makers introduced them just a few years ago. Dobsonians put big telescopes into amateur hands. The reasons for their popularity are manifest: thin glass mirrors are less expensive and lighter than ordinary mirrors; the compact mount means you can stick a big telescope in your car; and best of all, the expensive machined parts have all been replaced by bits of Teflon plastic.

Dobsonians also lowered the average cost of telescopes enormously — very important in the current economic hard times. For a typical equatorial Newtonian, a good mount costs about four times the cost of the telescope's optics — but a complete Dobsonian costs only one-and-a-half to two times the cost of the optics, and uses less expensive optics to boot.

Dobsonians are also easy to build at home. You don't need a machine shop, or a lathe, or a drill press. A screwdriver, saw, and hammer will do — so there is a big resurgence of home-built telescopes. A revolution of this sort is bound to hurt a few manufacturers — but then the buggy whip manufacturers didn't appreciate the automobile, either.

Craftsmanship: Dan Raether and Carl Blue built a 17½-inch Dobsonian in birch and birch plywood.

In the long run, however, what's good for amateur astronomers is good for the manufacturers, too. Why? Over the long run, everyone who *builds* a telescope and enjoys using it will probably *buy* at least one commercial telescope during his or her lifetime.

The Equatorial Revolution

Dobsonians have figured in another revolution, too — a revolution in equatorial mounts. They have virtually eliminated the terrible, shaky pipe equatorials of the forties, fifties and sixties. They have not replaced equatorial mounts — merely given visual observers a solid alternative to a poor equatorial mount.

Those equatorials that *are* being built are better. After being exposed to the stability inherent in a Dobsonian mount, an equatorial that shakes too much stands out. Equatorials are no longer the *sine qua non* for general purpose telescopes, but are seen instead as a specialized and fairly expensive type of telescope mount. Increasingly, builders who *want* an equatorial design them to accomplish a specific job — such as precision tracking for astrophotography or photometry — and therefore design them more carefully.

And finally, nearly fifty years after Russell W. Porter wrote on making a solid equatorial mounting, there is a firm manufacturing a solid equatorial. The Byers 812 mount will revolutionize astrophotography — not because it does something amateurs couldn't do before, but because it makes guiding very easy.

Suddenly, the rules of the game have changed. Whereas an amateur astronomer of five years ago might have spent several years acquiring enough skill to take a perfectly-guided photograph with off-the-shelf equipment, really solid mounts make guiding secondary. The astrophotographer is now faced with a radical new option: to photograph whatever he or she wants to on a routine basis.

The Deep-Sky Revolution

What did people observe with their telescopes ten or twenty years ago? The sky is the same, so the obvious answer is, "The same stuff we observe now." But that's not so. People are using telescopes for different purposes than they did a decade ago. Deep-sky observing has blossomed. Deep-sky photography has blossomed. Searching out faint galaxies and nebulae has become a popular esoteric sport. Going beyond the Messier catalog, even beyond the NGC, is possible with big Dobsonians. Messier marathons are not exactly commonplace, but nobody had even thought of them ten years ago!

That's not to say nobody ever looks at the Moon and planets today, but twenty years ago, those were the big things — plus observing double stars and splitting close binaries to test the quality of homemade optics.

What has this done to telescopes? Consider the average focal ratio of telescopes twenty years ago: it was much closer to f/8 or f/10 than it is now. Nowadays we're living in an era of f/5 Newtonian telescopes. What happened? Long f/ratio mirrors are easier to make — so if you grind your own, you're better off making a long focal ratio. But deep-sky observers want low magnification, so they choose short focal ratios. The resulting telescopes are also more portable and better suited for deep-sky astrophotography.

Stellafane meetings in the middle sixties often featured home-built Cassegrains and Maksutov telescopes. What happened to them? They're gone — victims of long focal ratios, high magnifications, and small fields of view. Victims, also, of the revolution in mass-produced commercial Schmidt-Cassegrains.

The Portability Revolution

Light pollution caused it. The average suburban/city backyard became too bright for satisfactory stargazing, and suddenly people wanted portable telescopes. Traditional homebuilts couldn't compete. Many were heavy things made with plenty of pipe — easy enough to drag into the back yard, but not suitable for carrying 25 miles out of town. When commercial Schmidt-Cassegrains hit the market, they sold well. Suddenly, for the first time ever, you could buy a pretty good 30-pound telescope with 8 inches of aperture. The 6-inch f/8 Newtonian — long the standard beginner's telescope — took a back seat.

But nothing stays the same for long. Dobsonians aren't as portable, but they are much bigger — and very portable for their size. The "serious deep sky" crowd, especially those on the West Coast, where mountains mean reliably clear, dark skies, realized that a 16-inch Newtonian could do things that no 8-inch could — like explore Stephan's Quintet or really see the spiral arms in M-51. Before Dobsonians, a 16-inch telescope was something you could move with a big truck; but in the Dobsonian era, it's a telescope for a small station wagon.

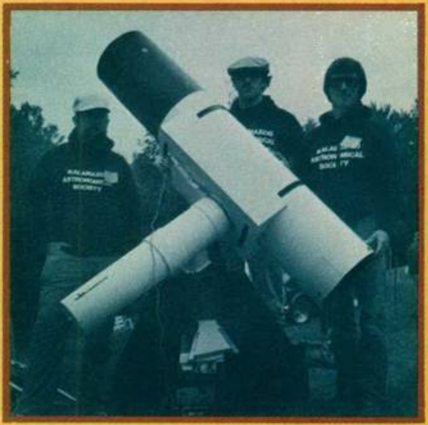
This revolution is not yet complete. Smaller Dobsonians are in the works. Just this year at the Riverside Telescope Makers Conference, Richard Shaffer showed a 17.5-incher that can fold down for transport in a Honda Civic; at Stellafane Ed Kaczanowicz showed another that slides back into itself; and Swedish telescope maker Ivar Hamberg completed one that collapses into a 24" x 24" x 30" package. The Dobsonian is not yet a "finished" design — it is still evolving.

The other side of the portability revolution is a growing appreciation of smaller apertures — the size range everybody used in the 1950s. Observers are resurrecting their old 60mm refractors from closets and basements, rediscovering the joys of binocular observing, dusting off long-abandoned 6-inch f/8 reflectors. Often this means tossing out the old pipe mount, remounting *a la Dobson*, and finding portability, stability, and observing pleasure in a small-aperture telescope.

The Eyepiece Revolution

There are three optical elements in a Newtonian telescope: the primary mirror, the diagonal, and the eyepiece. Superb mirrors have long been available, but eyepieces of equivalent quality are a recent introduction. Eyepieces are now better — the resulting views wider, darker, and crisper. Observing pleasure is vastly greater. The current generation of eyepieces — including such gems as University's 32mm Konig,

Portability: Ed Kaczanowicz removes the front half of the tube, turns it around and slides it into the back.



Equatorials: Kevin Hotton and Jack Roach built this sturdy mount for a 10-inch with $150 of materials.

Portability: A telescope that folds down to fit in a small car — Rick Shaffer's 17½-inch Dobsonian.

Meade's 20mm Erfle, the Tele-Vue Plossls, and Edmund's cost-effective RKE line — makes an optically good telescope a far finer instrument than did the Ramsdens, Kellners, and Orthoscopics of past decades.

The growing market for quality eyepieces will certainly bring still better products into production — with wider fields, sharper images, and better eye relief. For the observer peering into an eyepiece, observing will become more fun and more satisfying.

The Finished-Mirror Revolution

In 1945, you could buy a finished 6-inch f/8 for $60, or purchase a complete mirror kit for under $10. In 1980, you could buy a finished commercial grade 6-inch f/8 mirror for $40, or pay $40 for a kit. In terms of constant dollars, the price of finished mirrors has fallen greatly since World War II.

Refractor: John Pons's 8½-inch f/15.6 achromatic was a feature attraction of the 1982 Riverside meeting.

Most people making a telescope today buy a finished mirror. With incontrovertible logic, it makes more sense, and it's another aspect of the revolution in telescope making. Undoubtedly, it's easier to make a telescope if you buy the most difficult part already done for you. Undoubtedly, you're "on the air" with your telescope much sooner. The problems begin with the second or third telescope — because low-price mirrors are available only in the common sizes and focal ratios. If you want an unusual focal ratio, if you want a mirror better than commercial grade, if you want Cassegrainian optics or mirrors for an unobstructed reflector telescope, they're available only at a premium or not at all.

So today a relatively small band — small, that is, compared to the stampede three decades ago — of dedicated amateur opticians continues to seek optical perfection. These people have perfected the art of making the big, thin mirrors that Dobsonians require, and can show you how to figure and test a mirror that's *really* accurate to 1/10 wave. They build tilted-component reflectors, figure fine Maksutov-Cassegrain optics, and have triggered another revolution.

The Refractor Revolution

Quietly, almost without being noticed, another revolution has begun — the resurgence of refractors. Small refractors went "out" in the early seventies when their prices went sky-high compared to much larger reflectors. They were suddenly too expensive for what they did.

Observers interested in seeing planetary and lunar detail have always claimed that a refractor can reveal more than a reflector of the same aperture. They cite the obstruction-free aperture and the closed tube as making the critical difference. But reflector buffs always criticized the "secondary spectrum" in even the best and most expensive doublet objective objectives, and praised the color-free images formed by mirrors.

Aperture: When you look in the front end, you see yourself reflected in a very large mirror.

Nonetheless, seeing is believing. As they get the chance to look through medium to large achromatic refractors at star parties, more and more amateur telescope builders opt for a refractor as "the next one for me." The craftsmen — such as R.E. Brandt — who make superb doublet objectives have no shortage of orders.

But there's a better way. If *three* glasses are combined to make a triplet objective, or apochromatic lens, it's possible to eliminate 90 to 95 per cent of the secondary spectrum that plagues doublet objectives. Alternatively, fluorite lenses let optical designers create nearly color-free doublets. Not surprisingly, it was a couple of amateur telescope makers, Roland Christen and Mike Simmons, who brought these superfine lenses to the attention of the world. Apochromatic objectives are as close to optical perfection — being closed-tube, unobstructed, and color-free — as you can get in a telescope today.

The Big Money Revolution

Before World War II, if you wanted a telescope and weren't rich, you built it yourself. After World War II, a small industry began. Early commercial telescopes were built in garages, basements, and old factory lofts. The firms that built them were the quintessential small businesses — often owned and operated by one man. But as astronomy became more popular, telescopes started to sell. Some businesses grew; some failed. For the first time, commercial telescopes began to give home-built telescopes real competition.

Commercial telescopes became big business with the "Celestronic" and the subsequent emergence of Celestron Pacific as a major force in the ready-built telescope market. Investors saw profits in telescopes, and a Swedish multinational bought them — and the firm became Celestron International.

This process may be continuing with the sale of Criterion Instrument Company to Bausch and Lomb. Bausch and Lomb is a giant in optics and precision equipment. They obviously hope to capture a large part of the amateur astronomy market.

What does this mean to amateur astronomers? In other fields, it has meant very low prices for a while as a big company "buys" the market by pricing their product far below its competition. It's a good investment if it means gaining a monopoly. Then prices rise.

So the result could be a narrowing of choices and the domination of the hobby by one giant if small firms go under in the face of unbeatable competition.

On the other hand, with a healthy economy, and open rather than cut-throat competition, it could mean a growing diversity of quality products in the market — products competing for the consumer dollar, with resultant improvements in both quality and price. We'll have to wait and see what happens.

The Future

Telescopes are wonderful machines. They're built of very basic, simple materials — glass, metal, wood, bakelite, plastic. The funny thing is that home-built telescopes are every bit as good as mass-produced ones. So though fashions may change, and companies come and go, telescope building is a hobby that's here to stay — and one in which "amateurs" will probably continue to *lead* commercial producers into new areas.

— *Richard Berry*

the backyard astronomer

taurus

Mercury

The closest planet to the Sun reaches greatest eastern elongation on December 30, but will become visible low in the evening sky by the middle of the month. Inferior conjunction comes on January 16, so this apparition will be fairly brief.

Mercury attains its highest elevation over the horizon on January 1 (7°, 45 minutes after sunset), but will be at least 5° high between the 24th of December and the 8th of January. Its azimuth lies a little to the west of southwest.

Late in December, Venus will join it, though not very closely: on the evening of December 30, Venus will be about 3° high and Mercury will lie 4° above and to the left of it.

In a telescope, Mercury's disk will remain nearly constant in size and rather small: it increases from about 5" of arc on the 15th to about 7" by the end of December.

Venus

Venus is hidden in the glare of the Sun until quite late in December, when it will emerge, very low in the west-southwestern sky, to join Mercury during the latter's short apparition.

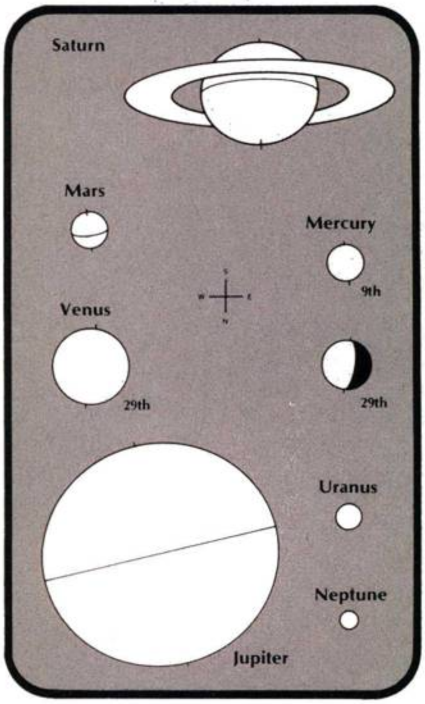
Earth

The Sun will reach its most southerly declination on December 22 at 4:39 UT. This marks the solstice and the commencement of winter for the northern hemisphere.

Moon

The total lunar eclipse in the early morning hours of December 30 will not be a replay of last July's (the weather alone will see to that!), but it does share a few similarities. For example, viewers on the west coast will be favored once again, as they'll be able to watch the entire event without interference from sunrise. But this eclipse is not as central as last July's: this time, the Moon will pass well to the north of the center of the Earth's umbra, which will shorten the duration of totality and possibly render the eclipse less dark.

To photograph the Owl Nebula (M-97) and the galaxy NGC-3556, Ronald Royer made three filtered black and white exposures with an 18-inch f/7 Newtonian. Then, by carefully printing each b&w negative through its appropriate color filter, Royer created this superb shot — December's "Best Astro-Photo."



From the east coast, the Moon will be setting during the entire eclipse, and sunrise will occur shortly after the total phase is over. Across the center of the continent, all of the umbral phases will be seen before sunrise, but you'll notice a definite lightening of the sky after the total phase ends as dawn begins. From the west coast and Hawaii, the Moon will be high in the western and southwestern sky, respectively, and the eclipse will end while the sky is still dark.

See the box on page 81 for the standard times of the events, and refer to Gazer's Gazette in the July issue for hints on how to observe a lunar eclipse.

Mars

If you look for Mars in the south-southwestern sky every evening at the same time relative to sunset, you'll see the planet hold a constant elevation during the entire month — about 20°, if you're looking 45 minutes after sunset.

Though this helps maintain Mars' naked-eye visibility, it doesn't do much to aid the telescopic observer who wants to look for detail on the planet's disk. Mars is a disappointment in the eyepiece right now, and things aren't going to improve much for many months.

Why? The planet is falling farther and farther behind the Earth as it follows its path around the Sun; its distance from us will increase until June 1983, when Mars reaches conjunction. Even when it emerges from the Sun's glare after conjunction, we won't get a really good view until Mars nears opposition in May 1984.

Asteroids

1 Ceres is in conjunction with the Sun on December 29th, and will be too close to it to be seen *until late in* January.

2 Pallas (magnitude 10.1) is in western Ophiuchus. Its positions:

9th: 16h 45m 37s, +3° 30.9'
19th: 17h 01m 08s, +3° 26.6'

Pallas rises around 6 a.m. local time on the 15th.

3 Juno (10.8) is moving eastward in northern Sagittarius. Its positions:

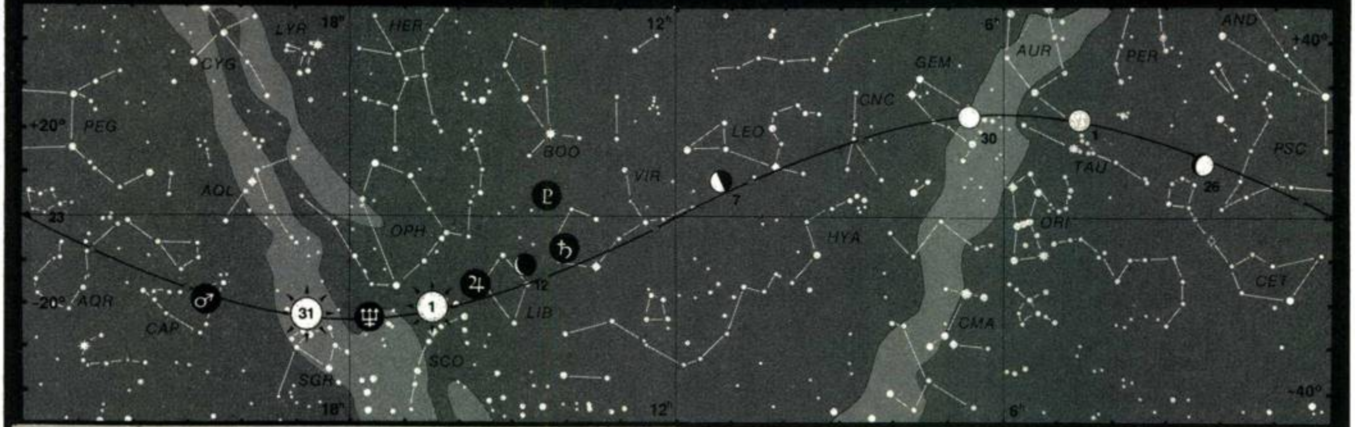
9th: 19h 24m 59s, -14° 13.1'
19th: 19h 40m 54s, -14° 00.3'

Juno sets soon after the Sun — around 6 p.m. local time at mid-month.

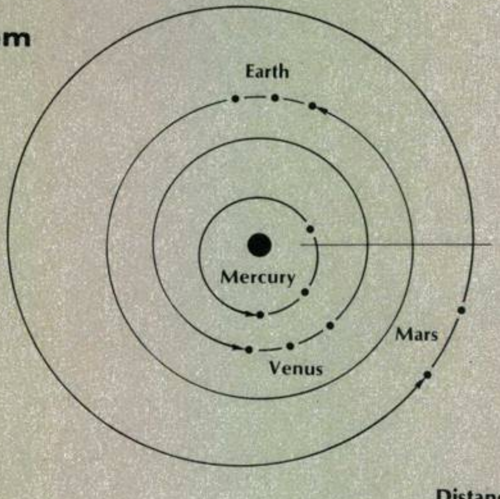
4 Vesta (8.1) lies in central Aquarius. Its positions:

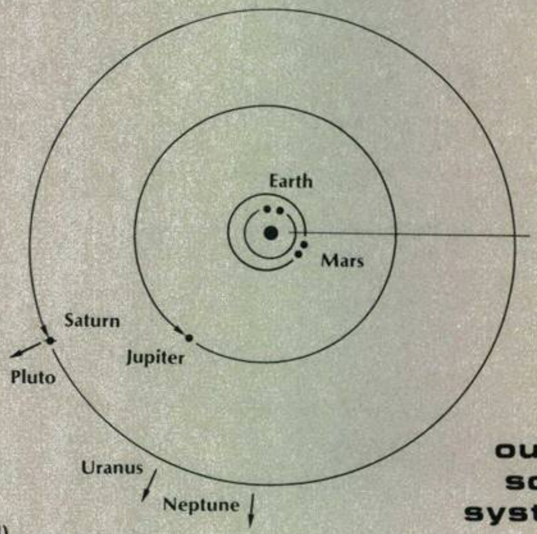
9th: 22h 11m 40s, -17° 54.7'
19th: 22h 26m 21s, -16° 21.6'

planetary data december 1982


LYR
18h
HER
12h
6h
AUR
AND
+40°
CYG
GEM
CNC
PER
+20°
PEG
LEO
30
1
PSC
BOO
TAU
AQL
VIR
26
23
7
ORI
OPH
HYA
12
-20°
AQR
31
1
LIB
CET
CAP
CMA
SCO
SGR
18h
12h
6h
-40°

inner solar system


Earth
Mercury
Mars
Venus


Earth
Mars
Saturn
Jupiter
Pluto
Uranus
Neptune

outer solar system

		Date	Mag.	Angular Size	% Illum.	Distance (AU) from: Earth	Sun	Longitude: Heliocentric	Ecliptic	R.A. (1983.0)	Dec
Sun		1	–26.8	32.5′	—	0.99	—	—	248°28.1′	16h 26.9m	–21°43.0′
		15	–26.8	32.6′	—	0.98	—	—	262°41.1′	17h 28.1m	–23°14.3′
		31	–26.8	32.6′	—	0.98	—	—	278°58.9′	18h 39.1m	–23°08.3′
Mercury	☿	1	–0.6	4.7″	99%	1.43	0.46	268°10.7′	254°16.2′	16h 52.9m	–24°01.3′
		15	–0.6	5.1″	91%	1.31	0.42	310°20.1′	275°58.1′	18h 28.5m	–25°31.5′
		31	–0.3	6.7″	59%	0.99	0.33	18°02.9′	297°55.6′	20h 03.7m	–21°37.7′
Venus	♀	10	–3.4	10.0″	99%	1.68	0.73	278°26.9′	265°58.8′	17h 44.3m	–23°56.4′
		31	–3.4	10.2″	97%	1.64	0.73	311°39.2′	292°20.7′	19h 39.3m	–22°43.9′
Mars	♂	15	+1.3	4.8″	94%	1.96	1.38	331°35.5′	303°14.9′	20h 25.3m	–20°34.0′
Jupiter	♃	15	–1.3	31.4″	100%	6.27	5.40	232°55.3′	237°15.5′	15h 42.6m	–18°51.0′
Saturn	♄	15	+0.9	16.2″	100%	10.32	9.73	206°51.7′	211°04.4′	14h 00.8m	–9°48.7′
Uranus	⛢	15	+6.0	3.5″	100%	19.86	18.91	245°06.7′	245°30.4′	16h 16.4m	–21°11.4′
Neptune	♆	15	+7.8	2.3″	100%	31.25	30.27	266°45.9′	266°09.9′	17h 45.4m	–22°11.3′
Pluto	♇	15	+13.9	0.1″	100%	30.46	29.92	207°16.0′	206°46.5′	14h 10.8m	+4°34.3′

moon data

Full Moon	December 1 at 00:21
Last Quarter	December 7 at 15:53
New Moon	December 15 at 9:18
First Quarter	December 23 at 14:17
Full Moon	December 30 at 11:33
Perigee: December 2 at 11h . .	360,166 km
Apogee: December 18 at 2h .	406,258 km
Perigee: December 30 at 22h . .	356,958 km

universal time

Astronomers the world over use an unambiguous system of time reckoning — Universal Time (UT) — based on a 24 hour clock. Times in The Backyard Astronomer are UT unless otherwise noted. To convert UT into your local standard time, subtract the following number of hours for each time zone: EST, 5; CST, 6; MST, 7; PST, 8; Alaska and Hawaii, 10. For example, if an event is to happen at 03:00 hours UT on February 2, then EST for the event is 10 p.m., February 1. Likewise, 03:00 UT on March 5 becomes, in PST, 7 p.m., March 4.

Vesta sets at about 10 p.m. local time on the 15th.

To facilitate plotting their positions on a star atlas, all asteroid coordinates are for the epoch 2000.0.

Jupiter

The commencement of another Jupiter observing season is always a delight — even if it does call for being outside at the telescope in the early morning hours. Though the planet will be low in the east-southeastern sky and difficult to see as December opens, it won't be long before you'll be able to spot it there, rising shortly before sunrise.

For using your telescope, though, you'll do better to wait a few weeks to let the planet climb higher, away from the clouds, hazes, and murky air near the horizon. By the end of December, Jupiter will be 20° high in the southeast, 45 minutes before sunrise, and a fine target for telescope users.

Saturn

Saturn's small but perfect appearance in an eyepiece seldom fails to take one's breath away. It doesn't matter how big or small the telescope is — the effect seems just as strong with a 60mm refractor as it does in a giant Dobsonian.

In overall appearance, Saturn's disk resembles a flattened oval. Oddly enough, although Saturn is actually more oblate than Jupiter, it doesn't often seem that way, perhaps because the rings add a distracting factor. The disk's colors are pale yellow and ivory, striped with slightly darker bands.

The rings are currently tilted toward us with their northern surface exposed. The angle of tilt will increase imperceptibly during December (from about 16° to almost 17°). The angular spread of the rings is just over twice that of the ball of Saturn: 37" of arc compared to 16".

Uranus

Emerging from the Sun's glare after conjunction, Uranus still lies fairly close to the bright double star Beta (β) Scorpii, but is moving steadily away from it toward the southeast.

Since this region now rises only a short time before the Sun, you'll have to look sharp to catch sight of the planet in the morning twilight. Try to locate Beta, then offset your scope about $1\frac{1}{3}$° to the south. From here, scan about 10 minutes of R.A. to the east and look for Uranus' 3.5" of arc disk.

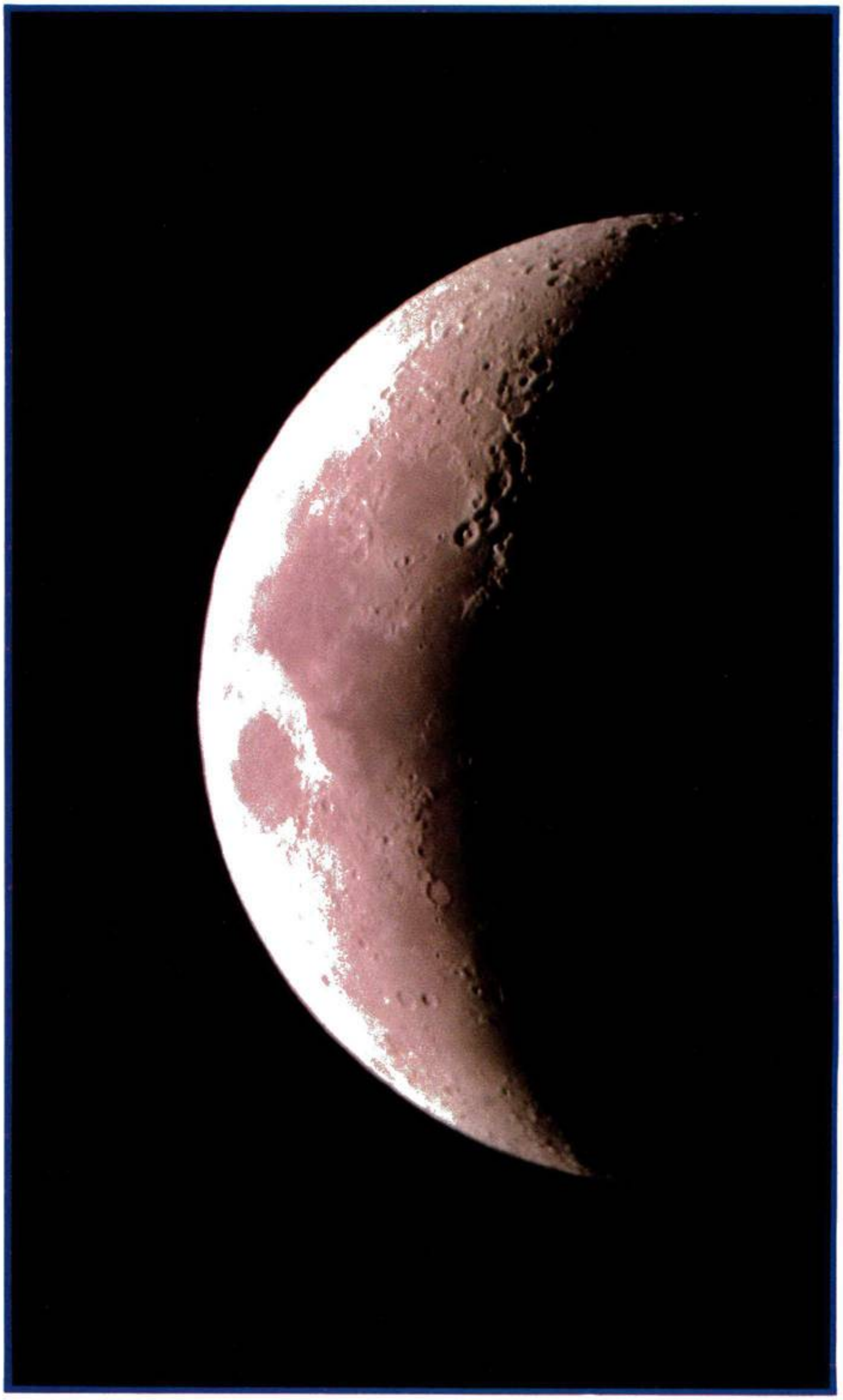
Neptune

Neptune is in conjunction with the

lunar eclipse times

	UT	EST	CST	MST	PST	AHST
Moon enters penumbra	8:52	3:52	2:52	1:52	12:52	**10:52**
Moon enters umbra	9:50	4:50	3:50	2:50	1:50	**11:50**
Totality begins	10:58	5:58	4:58	3:58	2:58	12:58
Mid-eclipse	11:29	6:29	5:29	4:29	3:29	1:29
Totality ends	11:59	6:59	5:59	4:59	3:59	1:59
Moon leaves umbra	13:07	8:07	7:07	6:07	5:07	3:07
Moon leaves penumbra	14:06	9:06	8:06	7:06	6:06	4:06

(PM times are in bold face)



The sunrise terminator has reached the eastern edge of Mare Serenitatis, throwing the mare's humped Serpentine Ridge into relief. In the south, the Altai Scarp curves around three craters: Theophilus, Cyrillus, and Catharina. Rick Kurczewski used a 16-inch f/5 scope and a $^1/_{60}$ second exposure on 200 ASA film.

Aug 21
Aug 22

Comet Austin's brief appearance in the evening sky late this summer inspired many to try for its picture. From left to right, the photos were taken by: John Bortle (August 21), Richard Steeg (August 22 and 23), Jack Marling (August 24), Dan Marcus and Bill Smith (August 25), and Andrew W. Steinbrecher (September 9).

Sun on December 19, and will be out of sight for the entire month.

Meteors

The two best annual meteor showers of December are the Geminids and the Ursids, with radiants in Gemini and Ursa Minor, respectively.

The Geminids' peak activity occurs when the Moon is nearly New: on December 14 at around sunrise for eastern North America. The zenithal hourly rate (the ideal maximum seen by one observer) is around 50 to 60, which compares favorably with August's famed Perseids. Anyone observing from an urban area, however, will see fewer meteors — but all the same, this is one of the year's best showers.

The Ursids, which peak on the 22nd, aren't quite as well-timed. The Moon won't set until nearly midnight, and the zenithal rate is only about 15 meteors per hour.

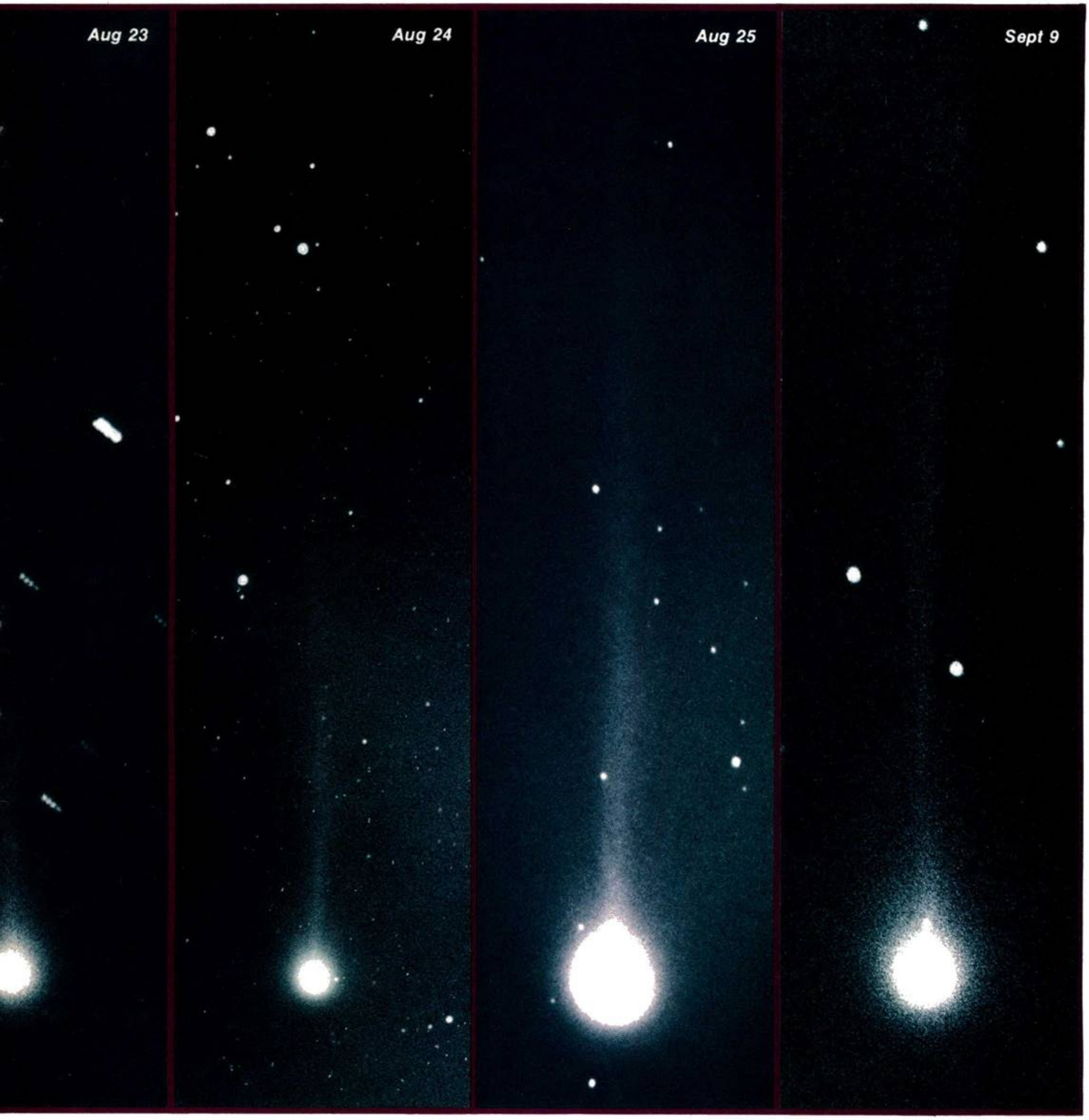
As with all meteor-watching, remember that the best numbers come after local midnight, when your observing site has rotated onto the leading hemisphere of the planet. Remember the analogy: it's the front of the car that catches the bugs!

close-up on taurus

One of the most elegant and attractive of the winter constellations, **Taurus** the bull is a dream come true for viewers of open star clusters. It contains no less than six bright, outstanding examples of this class of deep-sky object. Surrounded by a huge tract of sky, which constitutes the central portion of the winter Milky Way and contains the bulk of this season's interesting objects, Taurus offers exceptional examples of objects as diverse as double and variable stars, open clusters, planetary nebulae, reflection nebulae, and supernova remnants. Whether you try to see these wonders of our Galaxy with a large or small telescope, they'll offer an amazing variety of shape, size, and brightness — but it is important that you view from a reasonably dark site.

The most striking telescopic sight within the entire region is the **Pleiades** star cluster (M-45), also known as the "seven sisters." This commanding object spans 2° — about four times the diameter of the Full Moon — and contains 250 stars, the brightest of which shine at third magnitude. Thus, M-45 is the most conspicuous naked-eye deep-sky object in the entire sky; most observers normally see about six to eight stars without optical aid, providing the sky is fairly dark. To best observe the Pleiades cluster you need not utilize your telescope's optics at all. A good pair of binoculars or your telescope's finder will provide the most pleasing view of the group, due to its large apparent size. With medium-aperture instruments of 6 to 10 inches, a wide-angle low-power eyepiece is essential, if you wish to view the entire diameter of the cluster's brightest stars. In an 8-inch f/5 system with a 32mm Erfle ocular, nearly the entire group can be seen — as can, on very dark nights, a faint nebulosity associated with the cluster. The nebulosity is **NGC-1435**, a bluish reflection nebula — a great cloud of dust, illuminated by the bright stars close by. Its extreme faintness is not surprising, since its light is merely reflected from dust grains. However, it can be glimpsed in large telescopes at superb observing sites.

Much larger than the Pleiades is the


Aug 23
Aug 24
Aug 25
Sept 9

NGC-1746

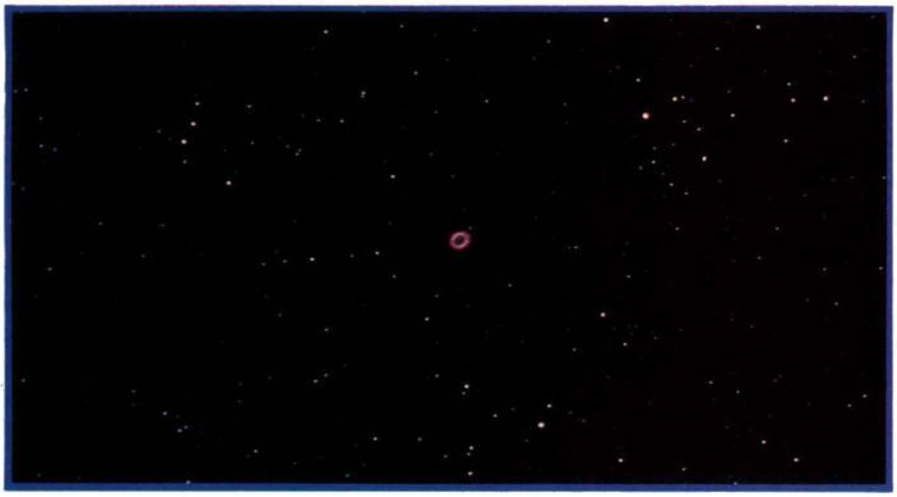
Lee C. Coombs

NGC-1514

Martin C. Germano

The Crab Nebula

Bill Iburg



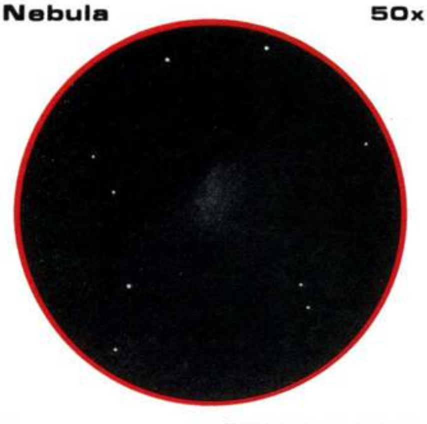
The Ring Nebula (M-57) in Lyra is sinking toward the northwestern horizon during December, though it is still visible early in the evening. Howard Zeh's photo captures the way the nebula looks in a small telescope at low to moderate powers — although your eye won't detect the colors revealed by the film.

Hyades star cluster, which measures 400′ of arc in extent. It has the largest apparent size of any open star cluster in the sky because of its proximity: some of the group's 245 members lie as close as 88 light-years away. The Hyades (Mel 25) presents a spectacular view in binoculars, but is rather dull in telescopes due to its huge apparent diameter. (See Eye on the Sky, page 42, in this issue for more information on the Hyades cluster.) Masquerading as a member of the group is **Aldebaran**, also known as Alpha Tauri, and familiar as the brightest star in the constellation — one of the brightest easily identifiable colored stars in the region. Aldebaran's beacon of orange light correlates to its stellar spectral type of K5; it shines so brightly not because it is intrinsically bright, but due to its close proximity, 68 light-years. The "eye of the bull" is thus at least 20 light-years nearer to us than any Hyades stars, and by chance only appears to be "inside" the cluster. Aldebaran is a double star, although its components are difficult to separate. The problem is that the secondary, at a distance of 31.4″, glows dimly at magnitude 13 — barely visible even in large amateur telescopes, due to the overwhelming light from the primary.

A number of other bright, interesting open clusters litter the region, although they are by no means as large as the Pleiades or Hyades systems. Again, use a wide-field ocular for these clusters to obtain the finest available view. Using high powers is fine for zooming in on a particular feature of a large cluster, but for an overall view, the best results are to be had with about 10x per inch of telescope aperture. **NGC-1647** contains 25 stars of magnitude 8 to 13 in an area measuring 40′ in extent. Another fine group is the slightly larger **NGC-1746**, which boasts 50 stars in an area of similar size. As with NGC-1647, its brightest stars are of the eighth magnitude. Two more open clusters, **NGC-1807** and **NGC-1817**, are closely situated and are slightly dimmer and smaller. NGC-1807 shines at magnitude 7.5 and holds only 15 stars in its 10′ area. NGC-1817 is slightly fainter but also larger, and displays 50 stars within its boundaries.

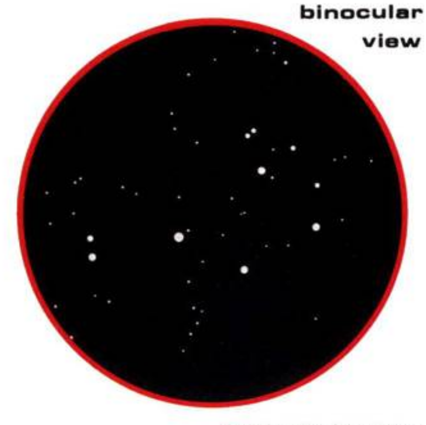
Several very curious objects in Taurus are rarely observed by amateurs. One is **NGC-1514**, an unusual faint planetary nebula. The chief problem in spotting NGC-1514 is the very low surface brightness of the tenuous gas that composes the nebulosity. A further complication is a relatively bright (tenth magnitude) central star involved with the nebula; it causes the same type of interference as was discussed with Aldebaran's secondary. However, with adequately dark skies and a moderately large telescope, it is possible to see this remarkable wisp of gas that once was part of the star. Use an accurate star atlas to locate the central star, then crank up the magnification of your instrument to 20 or 25x per inch of telescope aperture; you may well be able to detect nebulosity.

The Crab Nebula 8-inch scope 50x



Sketch by David J. Eicher

The Pleiades 7x50 binocular view



Sketch by David J. Eicher

T Tauri is a very unusual star. It is the prototype of a class of highly erratic variable stars, and fluctuates between magnitudes 9 and 13 at bizarre irregular intervals. Sometimes it changes wildly within several weeks; at other times it remains constant for months on end. Interestingly, a nebula — **NGC-1555** — is associated with this strange star; it varies in brightness in correlation with the star. "Hind's Variable Nebula," named after its discoverer, is difficult to see in amateur instruments, but is nevertheless a fascinating subject.

Our final Taurus object is one of the best studied in the northern sky — M-1, the **Crab Nebula**. This is the faint fuzzy patch which, in 1758, spurred French comet hunter Charles Messier into starting a catalog of nebulous objects. Since that time, astronomers have discovered much about the Crab's nature. It has quite definitely been linked to the 1054 supernova recorded by astronomers in China. At magnitude 8.4, it is the brightest optical supernova remnant in the sky. Observatory photographs taken several decades apart show a noticeable expansion in the gaseous filaments.

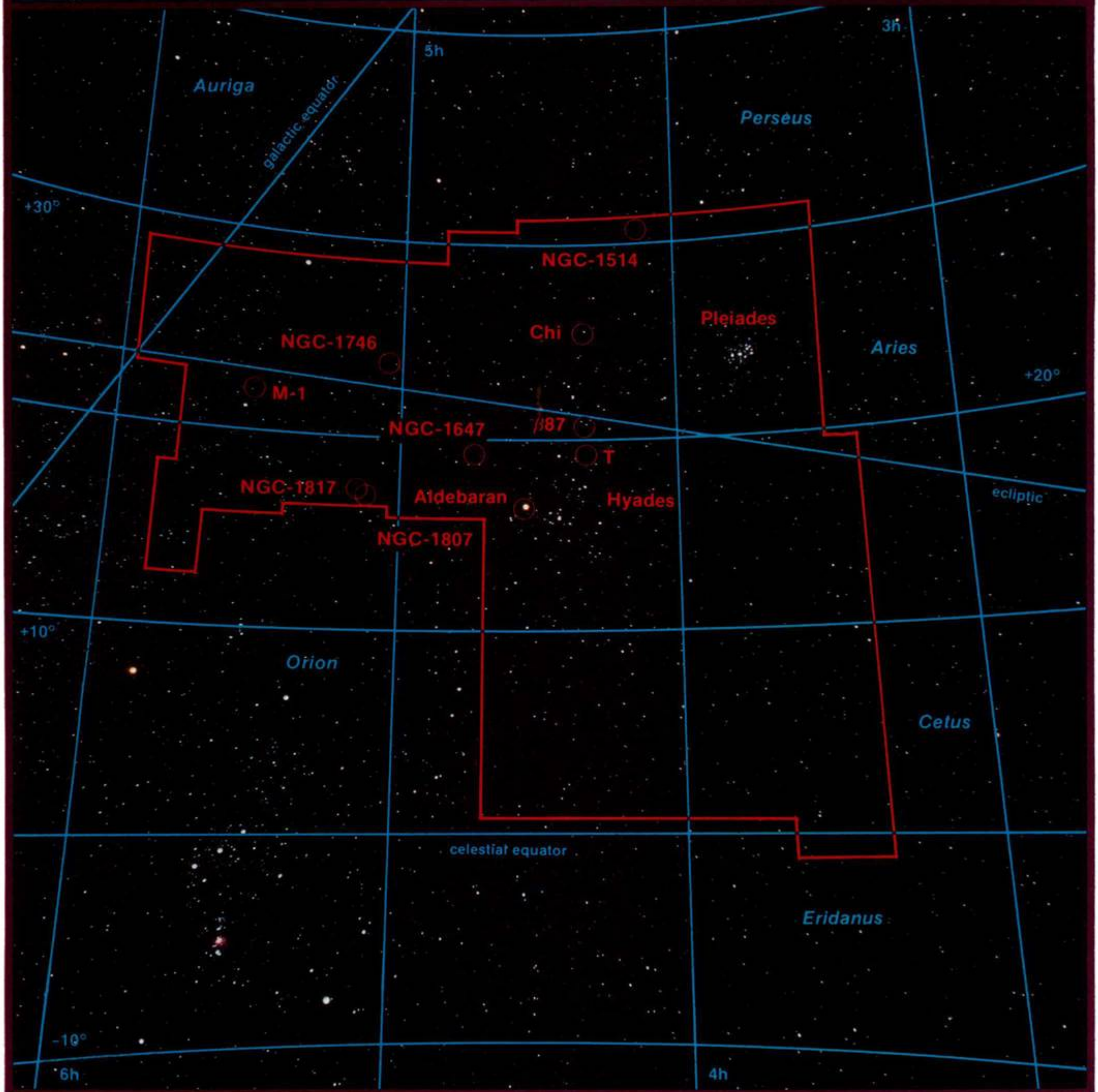
The Crab is not a spectacular eyepiece object, but it does appear as a fairly bright oval patch in 6 to 8-inch telescopes. Using high power in larger instruments, M-1 almost begins to show structural detail; this makes for a superb view.

Taurus is so splendid a constellation for deep-sky observers that it is impossible to detail all of its interesting objects. If you would like to explore this region more thoroughly, you would do well to read the Taurus section of *Burnham's Celestial Handbook* — or simply scan the region using a map such as the *Sky Atlas 2000.0*. Braving the holiday cold may well keep down your observing time, but if any heavenly attraction will keep you at your frosty eyepiece, it surely will be the spectacular region of Taurus the bull.

taurus

Photo by Robert Provin and Brad Wallis

Map by Robert Burnham


5h
3h
Auriga
galactic equator
Perseus
+30°
NGC-1514
Pleiades
Chi
NGC-1746
Aries
+20°
M-1
NGC-1647
β87
T
NGC-1817
Aldebaran
Hyades
ecliptic
NGC-1807
+10°
Orion
Cetus
celestial equator
Eridanus
-10°
6h
4h

Object	Type	Mag.	Size/Sep. Per.	R.A. (1950)	Dec.	R.A. (2000)	Dec.
The Pleiades	○	1.4	120′	03h44m	+23°58′	03h47m	+24°07′
NGC-1514	■	9.0	2′x1.5′	04h06m	+30°38′	04h09m	+30°46′
The Hyades	○	0.8	400′	04h15m	+15°27′	04h18m	+15°35′
T	∩★	9.4-13.0	Irr	04h19m	+19°25′	04h22m	+19°32′
β87	★^{2}	6+9	2.0″	04h19m	+20°42′	04h22m	+20°49′
Chi (χ)	★^{2}	5.5+7.5	19.5″	04h20m	+25°31′	04h23m	+25°38′
Aldebaran	★^{2}	0.8	31.4″	04h33m	+16°25′	04h36m	+16°31′
NGC-1647	○	6.0	35′	04h43m	+18°59′	04h46m	+19°04′
NGC-1746	○	6.0	45′	05h01m	+23°44′	05h04m	+23°48′
NGC-1807	○	8.5	17.5′	05h08m	+16°28′	05h11m	+16°32′
NGC-1817	○	8.0	20′	05h09m	+16°38′	05h12m	+16°42′
M-1	□	8.4	6′x4′	05h32m	+21°59′	05h35m	+22°01′

★	*Star*
★^{2}	*Double Star*
★^{3}	*Triple Star*
m★	*Regular Variable*
∩★	*Irregular Variable*
Ӿ★	*Eclipsing Variable*
○	*Open Cluster*
●	*Globular Cluster*
■	*Planetary Nebula*
□	*Bright Diffuse Nebula*
§0	*Elliptical Galaxy*
§S	*Spiral Galaxy*
§ʃ	*Barred Spiral Galaxy*
§#	*Peculiar/Irregular Galaxy*

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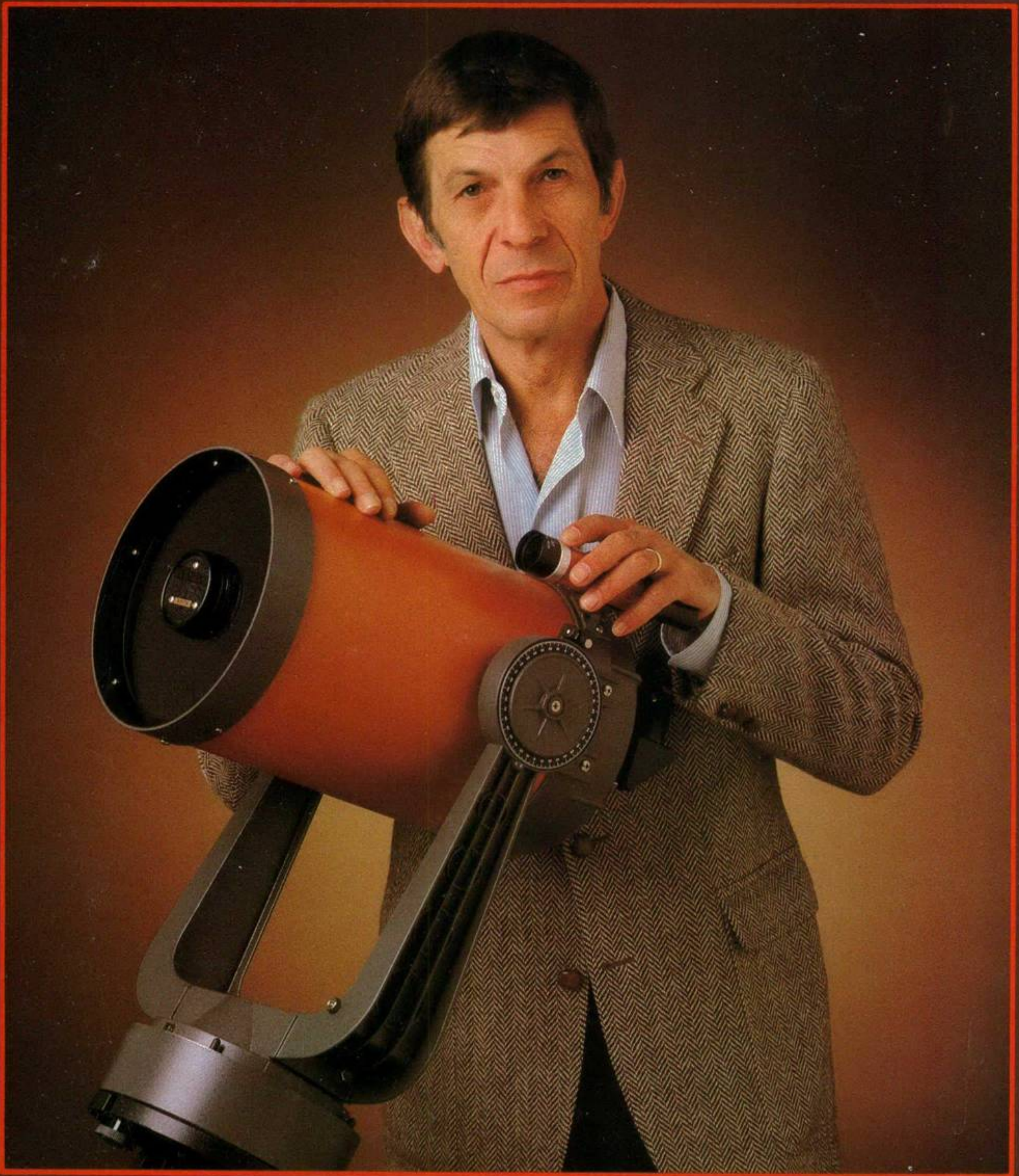

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